Transport Canada Transports Canada

Handbook for Civil Aviation Medical Examiners

http://www.tc.gc.ca/aviation/cam/e_index.htm

Également disponible en français sous le titre de :
Guide pour les médecins examinateurs de l'aviation civile

Canada

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RECORD OF AMENDMENT

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NOTE
This handbook has been produced at Civil Aviation Medicine Headquarters in Ottawa.
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Civil Aviation Medical Standards

The history of medical standards in civil aviation dates back to just after World War I when the International Commission on Air Navigation (ICAN) was established following the Paris Air Convention of 1919. This organization was set up to establish rules and regulations for the safe conduct of civil aviation. ICAN established a medical sub-commission which set about producing the first ever medical standards for civil aircrew which were extremely strict. In 1944, towards the end of World War II, the International Civil Aviation Organization (ICAO), an agency of the United Nations, was formed to carry on the work of ICAN, which had ceased to exist during World War II. Over the years, the international standards and those of Canada have become more liberal to the point now that the majority of the population over the age of 16, if they so wished, would pass aviation medical certification examinations.

In Canada, the regulations pertaining to medical requirements are contained in Part 404 of the Canadian Aviation Regulations (CARs) while the actual medical standards are in Part 424 of the Canadian Aviation Regulations. Both Part 404 and Part 424 form part of this *Handbook*. CAR 424.05 permits the Civil Aviation Medicine Branch to exercise flexibility in medical certification of pilots and air traffic controllers who technically do not meet the standard, but whom *accredited medical conclusion is such that the failure to meet the standard is such that the exercise of the privilege of the licence is not likely to affect air safety.*

Over the years, guidelines have been produced in the major areas which cause problems with aeromedical certification, namely neurology, cardiology and diabetes. A copy of these guidelines is available in this Handbook.

In your role as a Civil Aviation Medical Examiner (CAME), you are usually the only person who physically examines the pilot and makes a recommendation for medical certification. You are therefore the most important link in the chain of safety in the medical certification process. While performing your CAME function, you are acting as an agent of the Minister of Transport, so Transport Canada will indemnify you for any litigation that may come out your aviation medical examination activity which is conducted in good faith. Recent changes in the medical certification process, and delegation of validation authority to the examiner have not been interpreted by the Canadian Medical Protective Association as increasing the exposure to litigation, and will therefore not result in increases to the CMPA premiums for CAMEs.

Accompanying this book is a video outlining the changes that will be taking place in the medical certification process, and showing you how to complete the Medical Examination Report form (26-0010) completely. The medical handbook part of this document is not a text on aviation medicine, it is merely an introduction to the subject and covers the basic facts that you must have to understand the medical problems associated with flight. It will help you deal with many of the questions you may be asked and hopefully will encourage you to further study the subject. More detailed information on the subject of aviation medicine can be obtained from the following books:

Aviation Medicine – J. Ernsting, A. Nicholson and D. Rainford, Third Edition (1999) – Butterworths.

Fundamentals of Aerospace Medicine by Roy L. De Hart (1996), Second Edition, Williams and Wilkins.

Aviation Medicine, R. Harding and J. Mills (1993). British Medical Journal Publishing Group.

Clinical Aviation Medicine, R. Raymond (1990) – Lea & Febiger.

Civil Aviation Medicine Branch has developed an Internet website which will be used more and more for the dissemination of information between the Branch and CAMEs. Those of you who have Internet access are welcome to browse the website and submit your comments. The address is:

http://www.tc.gc.ca/aviation/cam/e_index.htm

SECTION 1

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Civil Aviation Medical Branch Organization and Administration

The Civil Aviation Medicine (CAM) Branch is one of several branches of the Directorate General of Civil Aviation in Transport Canada. The Director of Civil Aviation Medicine reports to the Director General of Civil Aviation.

CAM Headquarters

CAM Headquarters is located in the Transport Canada Building, 330 Sparks Street, Tower "C", Place de Ville, Ottawa, K1A 0N8.

The **mandate** of CAM is *to provide medical advice and assistance in setting out physical standards for Civil Aviation personnel; to advise in all problems connected with the health of travellers by air.*

The **mission** is *to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and safety in the field of aviation and to prevent aircraft accidents due to medically related human factors.*

CAM Regional Offices

There are currently four Regional offices across Canada located in Montreal, Toronto, Edmonton, and Vancouver. The Edmonton, Toronto, and Montreal offices are under the direction of a Regional Aviation Medical Officer (RAMO) while the office in Vancouver is staffed by an Aviation Medical Officer. The RAMOs are responsible for the selection and training of CAMEs, for reviewing the medical examination of pilots, flight engineers, and air traffic controllers, and for approving an appropriate medical category for aviation personnel. CAM does not issue

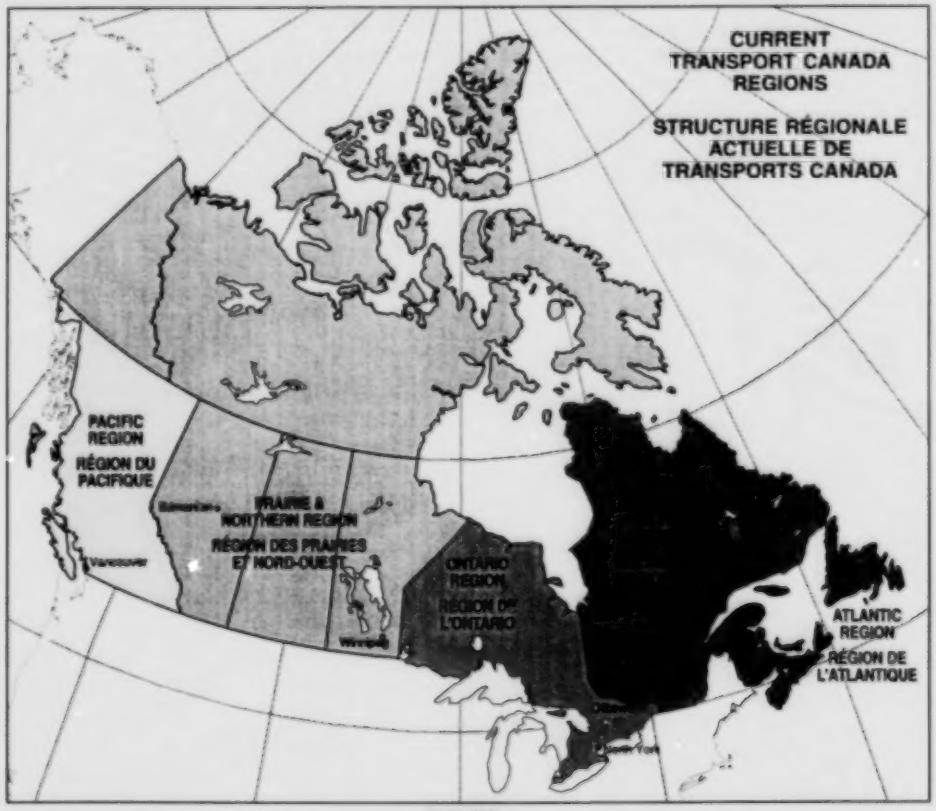


FIGURE 1

licences, it issues Medical Certificates (MCs). Licensing is a responsibility of Transport Canada, General Aviation. As a CAME, you may now renew MCs for the full validity period of licensed aviation personnel for **renewal** medical examinations only. Initial medical examinations, Category upgrades and removal or addition of restrictions to a license must still be deferred at the CAME level and sent to the RAMO for approval.

Licensing

All pilots, flight engineers, and air traffic controllers must be licensed by Transport Canada, General Aviation Branch. After completing such requirements as flight training, written examinations, and flight tests, an applicant is granted a licence by the department. Licences do not have a validity period, but must be validated by a current MC which has a limited duration. There are four medical categories shown on the medical certificate, each of which validates a different type of licence. The types, the required medical categories and the validity periods of the licences are shown in the *Medical Examination Requirements* Table. (Figure 2)

Civil Aviation Medical Examiners (CAMEs)

CAMEs are appointed on the basis of need, by the RAMO or AMO on behalf of the Minister of Transport. Interested physicians apply to the CAM office in their region and are interviewed by the RAMO prior to appointment. If accepted as a designated CAME, they must await the receipt of the official letter of appointment before performing any aviation medical examinations. The letter of appointment will be sent together with a full CAME authority package, including this *Handbook*, a CAME numbered stamp and a wall certificate. All CAMEs who are newly appointed will be required to attend a training seminar at the earliest opportunity, and then no less than **once every four** years.

Aviation medical examinations may only be carried out by a CAME. In the case of pilots residing overseas, the examination may be carried out by a medical examiner approved by the licensing authority of a contracting state of the International Civil Aviation Organization (ICAO). Appointment of CAMEs in areas outside Canada is at the discretion of the Senior Consultant, Operations, Policy and Standards, of Civil Aviation Medicine Branch or the Director of Civil Aviation Medicine.

All CAME appointments are valid for a period of four years, renewable upon the recommendation of the RAMO. Re-appointment will depend on the quality and timeliness of reports, demonstrated continuing interest in aviation medicine, and feedback from the aviation community. There must also be a continuing requirement for services in the CAME's designated geographic area.

Termination of Appointments

It is rare for a CAME appointment to be terminated. If there are significant problems with the quality of the medical information being submitted, the RAMO will contact the CAME and take whatever remedial action is necessary to assist in solving the problem.

Appointments may be terminated for any of the following reasons:

1. Frequent or continual low quality professional performance.
2. Failure to provide reasonably prompt service.
3. Unethical conduct.
4. Loss or suspension of medical licence.
5. Prolonged inability to provide service due to ill health or disability.
6. Change of geographic location.
7. Voluntary relinquishment of the appointment by a CAME.

CAMEs may, at any time, request that their appointment be terminated.

FIGURE 2

Medical Examination Requirements

Licence or Permit Type	Medical Category	Age	Medical Report	Audiogram	Age	Electrocardiogram
Airline Transport Senior Commercial Commercial	1	Under 40	Within twelve months of issue or revalidation	At first examination then at 55 years old	Under 30	At first examination
		Over 40	Within six months of issue or revalidation		30-40	At first examination and every two years thereafter
(Validates all other categories)					Over 40	At first examination and every year thereafter
Flight Navigator Flight Engineer Air Traffic Controller	2	Under 40	Within two years of issue or revalidation	At first examination then at 55 years old	Under 30	At first examination
		Over 40	Within twelve month of issue or revalidation		30-40	At first examination and every two years thereafter
					Over 40	At first examination and every year thereafter
*Student Pilot Private Pilot Gyroplane Pilot Free Balloon Pilot	3	Under 40	Within five years of issue or revalidation	(If clinically indicated)	Under 40	N.A.
		Over 40	Within two years of issue or revalidation		Over 40	At first examination and every four years thereafter
Ultra Light Instructor	3		Within five years of issue or revalidation	(If clinically indicated)	Under 40	N.A.
Glider Instructor					Over 40	At first examination and every five years thereafter
Glider Pilot Ultra Light Pilot	4		Medical Declaration (Full MER only if clinically indicated)	(If clinically indicated)		N.A.
Recreational Pilot Student Pilot	4		Medical Declaration or Form 26-0297 countersigned by a physician	(If clinically indicated)	Under 40	N.A.
					40-50	At first examination
					Over 50	At first examination and every four years thereafter

NOTE: The holder of Medical Category 1 shall be considered fit for any permit or licence for its respective duration of validity unless otherwise specified

The Medical Examination

It is your responsibility to interview and perform a complete examination on all applicants for aviation medical certification. You may be the only physician in the normal course of events who has talked to the pilot and had a "hands-on" opportunity to form an impression. Although the Medical Examination Report form (MER) may look similar to others you have completed for insurance examinations, your input here is much more valuable and is of immediate importance.

Since pilots and air traffic controllers are at risk of losing their medical certificate, and in some cases their employment, each time they present themselves for a medical, they naturally find aviation medical examinations threatening. For this reason, we recommend that you and your staff do all in your power to put the applicant at ease prior to the examination. This examination is always stressful and often becomes more stressful as pilots grow older.

Pilots, although not basically dishonest, may not volunteer information which may affect their medical certification. They will, however, respond to direct questions and will sometimes give you much more information than you expect if you convince them that your prime interest is keeping them in the air. Sometimes they have problems that may affect their medical certification that they would like to discuss with someone of good will. Of particular importance in the interview is any suggestion of substance abuse, mental instability, lack of insight or inappropriate reactions. You have an opportunity to decide whether this is the type of person with whom you would fly or to whom you would entrust your family. Remember, that the next time you climb on board as a passenger this may be your Captain!

Normally when you deal with patients you are concerned with their immediate health. In aviation a more important concept is that of sudden and/or subtle incapacitation. This may arise from such diverse stresses as the pain of acute renal colic or the subtle loss of judgment that results from an occult brain tumor. A pilot in trouble in the air cannot stop and pull over to the side of the road until the symptoms pass! A point to bear in mind is that in annual medicals we are chiefly concerned with the short term, that is, the validity period of the medical certificate.

The medical examination is recorded on the form, Medical Examination Report 26-0010 (MER), the original of which should be sent to the Regional office. The MER is available in both English and French and is periodically updated. The effective date is located in the lower left corner of the form as (1999-03). Blank forms are available upon request from the Regional offices.

The MER is reviewed in the Regional office. If the MER is not complete or if there are errors or omissions, it will be returned for correction. The original form should then be corrected and returned to the Regional office.

The next few pages will help you to fill out the MER and indicate the type of answers required. There is also an Appendix on the visual examination. This seems to be the most difficult part of the examination and so befits greater explanation. Hopefully all else will be clear after your first seminar but, if in doubt, your RAMO is no further away than your telephone (See contact numbers –Toll free).

A useful reference is the *ICAO Manual of Aviation Medicine* produced by the International Civil Aviation Organization. Copies of this can be obtained by writing to the following address:

(The manual is currently being revised)

Document Sales Unit
International Civil Aviation Organization
999 University Street
Montreal, Quebec
H3C 5H7

Transport Canada / Transports Canada

PROTECTED WHEN COMPLETED

CIVIL AVIATION MEDICAL EXAMINATION REPORT

Region

File number 5802 -

PART A (TO BE COMPLETED BY APPLICANT)

Type of Permit / Licence desired (If A.T.C. state position)	Aviation Permit / Licence held (Type)	Permit / Licence Number	Telephone number: Home ( )	Business ( )
Given names	Familyname		Former surname	
Address (Number, street, apt)	City, Province		Country of residence	Postal code
Has your mailing address changed since your last medical? ☐ Yes ☐ No	Date of birth (Y/M/D)	Place of birth (Country) ☐ Male ☐ Female	Citizen of (Country)	Education
Occupation	Employer	PILOT FLIGHT TIME: Last 90 days / Last 12 months / Total		
Have you had an aircraft accident since you last civil aviation medical examination? ☐ Yes ☐ No Date (Y/M/D)	Place		Aircraft Registration Marks	
Have you consulted a physician since your last aviation medical examination? If yes, give reason.	Have you ever been refused issue or renewal of a Civil Aviation Licence for medical reasons? ☐ Yes ☐ No		Date of last Audiogram (Y/M/D)	
	Are you receiving a pension or compensation for injury? ☐ Yes ☐ No		Date of last E.C.G. (Y/M/D)	
	Last Civil Aviation Medical Examination Date (Y/M/D)		Place (City, Province) or Country	
Primary Type of flying intended ☐ Recreation ☐ Business ☐ Career	Language of Aeronautical Publications ☐ English ☐ French			

PART B (TO BE COMPLETED BY EXAMINER)

Is there a familyhistory of:	Yes	No
1. Mental illness		
2. Cardiovascular disease or hypertension		
3. Diabetes		

Details - To be completed by Medical Examiner

C.V. risk factors Examiner please check (✓)

Familyhistory		Smoking	
Hypertension		Diabetes	
Obesity		Serum Lipids	

REVIEW OF SYSTEMS

Has the applicantever had or beentreated for any of the followingconditions?

	Yes	No		Yes	No
1. Head injury, dizziness, loss of consciousness			9. Gastrointestinal disorders		
2. Frequent or severe headaches			10. Musculo - skeletal disorders		
3. Epilepsy			11. Menstrual disorders		
4. Psychiatric/neurological problems			12. Alcohol or substance abuse		
5. Ear disease or deafness			13. Any other medical conditions		
6. Allergies			14. Current medications (Prescriptions or OTC)		
7. Pulmonary disorders including asthma			15. Does the applicant smoke more than 5 cigarettes per day?		
8. Cardiovascular disorders including hypertension			16. Weekly alcohol intake (units)		

Examinerpleaseelaborate

List injuries, operations, serious illnesses and dates

STATEMENT OF APPLICANT

I hereby declare that I have read and understood the above information which to the best of my knowledge is complete and correct. I recognize that this report and any other medical documentation submitted or authorized to be submitted by me as part of my application for licence or permit is the property of Transport Canada Civil Aviation Medical Advisors.

I authorize the release of any information contained herein or in other relevant medical reports, including electrocardiograms, audiograms, specialist reports and other relevant medical information to Transport Canada, Civil Aviation Medicine Branch, for the sole purpose of establishing my medical fitness to hold a licence or permit issued by Transport Canada. I am aware that it is an offence under the *Aeronautics Act* to knowingly make a false declaration.

Date (Y/M/D) _____ Applicant's Signature _____ Witness _____

PART D: CIVIL AVIATION MEDICAL EXAMINER'S RECOMMENDATION (TO BE COMPLETED AFTER MEDICAL EXAMINATION)

RECOMMENDATION

Please tick (✓) ☐ Fit ☐ Deferred

Category ☐ 1 ☐ 2 ☐ 3 ☐ 4

Remarks

	Yes	No
Was a renewal assigned?		
Do you recommend further examination?		
Are you sending a separate confidential report?		
Has the last renewal box on the medical certificate been used?		

CAME Stamp

Date (Y/M/D) _____ ( ) Telephone _____ CAME Signature _____

26-0010 E2 (0108-03)

Canada

PART C: (TO BE COMPLETED BY EXAMINER)

Name	Licence No.

PHYSICAL EXAMINATION

Height cm	Weight kg	Colour of hair	Colour of eyes	Blood pressure(s)	Identifying marks

Check each item	Norm	Abnor	Elaborate on each abnormal response with diagnosis if possible
1. Nutrition			
2. Nose and throat			
3. Ears			
4. Respiratory system			
5. Cardiovascular			
6. Gastro intestinal			
7. Genito-urinary			
8. Locomotor			
9. Neurological			
10. Mental status			
11. Integument			

VISUAL EXAMINATION

		ACUITY	Glasses	Contact lenses
Distant	Right eye	/ Corrected to	/	/
	Left eye	/ Corrected to	/	/
	Both eyes	/ Corrected to	/	/

	Normal	Abnormal
Optic fundi		
Visual fields		

Near (N5 @ 30-50 cm)	Uncorrected		Corrected	
	Yes	No	Yes	No
Right eye				
Left eye				

OCULAR MUSCLE BALANCE	
Ortho _____	Eso _____
Hyper _____	Exo _____
Cover Test	

Lens Prescription	Sphere	Cylinder
Right		
Left		

	Yes	No
Do you recommend an eye specialist examination?		

COLOUR PERCEPTION EXAMINATION

Pseudoisochromatic Plates	Type	Number of plates	Number of errors

HEARING EXAMINATION

Whispered voice (Record distance in meters) Right _____ Left _____

AUDIOGRAM/ AUDIOSCOPE (if applicable)

HZ	500	1000	2000	3000	4000	6000
Right						
Left						

URINALYSIS

Glucose	Other

OTHER TESTS, COMMENTS, ETC.

RAMO ASSESSMENT (DEPARTMENTAL USE ONLY)

Comments/ Restrictions

		P	V	C	H
1st Category	Suffix				
	Code(s)				
2nd Category	Suffix				
	Code(s)				

Path Code(s) _____ _____

Date _____ (Year) _____ (Month) _____ (Day)

RAMO Signature _____

APL

Entered in NAMIS	Date

Completing the Medical Examination Report

This section deals specifically with the completion of the form.

PART A

REGION AND HQ FILE NUMBER
– These blocks will be completed by the Region.

TYPE OF LICENCE DESIRED
– Indicate any of the types listed in Fig. 2.

AVIATION LICENCE HELD
– Indicate any of the types listed in Fig. 2. Initial applicants should have "NIL" indicated here.

LICENCE NUMBER
– Enter the applicant's licence number if available.

TELEPHONE NUMBER
– Indicate numbers with area codes, Fax, e-mail.

NAME, FAMILY NAME AND FORMER SURNAME
– Complete legal names should be indicated here. Initials and nicknames cause confusion.

ADDRESS, CITY\COUNTRY, PROVINCE, POSTAL CODE
– Full addresses are required. Abbreviations should not be used.

PROVINCE OF RESIDENCE
– Self explanatory.

DATE OF BIRTH
– Self explanatory.

PLACE OF BIRTH (COUNTRY)
– Indicate the country only.

MALE/FEMALE
– Self explanatory.

CITIZEN OF
– Indicate citizenship.

EDUCATION
– Indicate highest level achieved e.g. Grade 12 (or University).

OCCUPATION, EMPLOYER
– Self explanatory.

PILOT FLIGHT TIME
– This can be very important. A hiatus or sudden change in flying time patterns may indicate an illness/injury which has not been revealed. Grand total is all the flying time since the applicant started flying.

HAVE YOU HAD AN AIRCRAFT ACCIDENT ...?
– Accident data is not kept on the Department of Transport pilot files. We rely on the information you provide. If the pilot answers yes, note whether there was a medical cause or any medical sequelae in the "Review of Systems" part of the form.

HAVE YOU CONSULTED A PHYSICIAN? REASON?
– Self explanatory.

AERONAUTICAL PUBLICATIONS
– Indicate the language preferred by the applicant.

PRIMARY TYPE OF FLYING INTENDED
– Recreation includes all non-business related flying. Business includes all business, commercial and military flying.

DATE OF LAST CIVIL AVIATION MEDICAL EXAMINATION
– Indicate date and place if known.

MEDICAL CATEGORY
– Indicate the medical category assigned to the applicant at the last medical certification.

DATE OF LAST ECG, CHEST X-RAY AND AUDIOGRAM
– Show the complete date if known.

B. Family History

This section is included to identify people at higher risk for genetic or familial diseases. Any "yes" answers require comment in the blank space provided. There is also a block here in which you can record cardiovascular risk factors.

Review of Systems

The functional inquiry is the basis for any good medical examination. This part should be completed by you. The questions, of course, are simply a guide and are not all inclusive. A positive response should be elaborated in the space below or, if there is insufficient space, on an attached sheet.

Statement of Applicant

This is a legal declaration that the applicant has supplied complete and accurate information. It releases the medical information on the MER and other reports to CAM and Transport Canada. The applicant must read, date and sign the declaration and the signature must be witnessed. The applicant should be aware that it is an offence under the Aeronautics Act to knowingly make a false declaration.

N.B. If you are examining the applicant for the first time ask for the some proof of identity.

PART D

Civil Aviation Medical Examiner's Recommendation

Most of this is self-explanatory. It is possible for a candidate who is an air traffic controller to have two categories such as 2 and 3, as the candidate could be also eligible for private pilot medical certification. The "remarks" area is for any observation or recommendation you wish to make. Part D should be signed at the end of the complete examination and must bear your personal CAME stamp.

PART C

General Physical Examination

This section should be completed by you although some portions, such as the height, weight and blood pressure may be completed by your staff. They must be trained and supervised as noted in the Canadian Medical Association (CMA) guidelines on the delegation of medical responsibilities. It is preferable that you perform the entire examination.

HEIGHT AND WEIGHT
– Use metric figures.

BLOOD PRESSURE
– This should be recorded while the applicant is sitting, using a cuff of appropriate size. If a non-standard cuff is used this should be recorded. The diastolic blood pressure to be recorded is the disappearance of the sound.

IDENTIFYING MARKS
– Note any surgical scars, tattoos or other marks. These may be useful for identification in aircraft accidents.

NUTRITION
– There are no Transport Canada standards for desirable or maximum weights of individuals. Record if the individual's stature would affect the ability to function in the flight environment.

NOSE AND THROAT
– The examination should be directed to the presence of any condition which would impair respiratory functions or pressure equalization during flight.

EAR DRUMS
– Examine for any pathology, perforations and for the adequacy of pressure equalization. Pressure equalization should be assessed by observation of the drum during a Valsalva maneuver. Vestibular function should be normal.

RESPIRATORY SYSTEM
– Self-explanatory.

CARDIOVASCULAR
– This should include an assessment of the peripheral circulation as well as the heart. A careful note should be made of any murmurs.

ABDOMEN INCLUDING HERNIA
– Rectal examination is not mandatory but, in keeping with good medical practice, is recommended for males over age 45. An assessment of the inguinal areas for hernia is necessary, since inguinal hernias are not considered safe in the aviation environment.

GENITOURINARY
– Self explanatory. Pelvic examination is not required.

LOCOMOTOR
– Pilot applicants should be assessed for the ability to undertake flight operations in normal and emergency situations. In the case of amputation or paraplegia, special practical tests will be ordered by the RAMO to determine the applicant's suitability for flight.

NEUROLOGICAL
– A screening examination with assessment of reflexes is required.

MENTAL STATUS
– This is an overall assessment of the psychological suitability for the aircrew of air traffic controller licence. A brief comment regarding an applicant's mental stability would be appreciated in the "Remarks" section.

INTEGUMENT
– skin etc.

Visual Examination

Note: An excellent outline of an aviation visual examination can be seen on the video, "The Vision Examination for Civil Aviation Medical Examiners" available from CAM Headquarters.

This should include examination of the external eye and direct or indirect ophthalmoscopy. Particular attention should be directed to the cornea to detect contact lenses and/or the scars of surgical procedures to correct refractive errors such as PRK and LASIK. Cycloplegic examination is not routinely required.

VISUAL FIELDS
– Assessment by confrontation is adequate.

Distant Vision Testing

The Transport Canada standards for vision are summarized in Fig. 3. Distant vision should be tested using Landolt Rings, a chart of Snellen letters or other similar opotypes situated at an optical distance of 6 meters using either an eye lane or an approved vision testing instrument. Where an eye lane is used, the test chart must be illuminated to a level equivalent to that provided by a 100 watt lightbulb placed 120 centimeters in front of, and slightly above the chart with the light shielded from the applicant. The examination room should be darkened with the exception of the chart.

The uncorrected vision should be tested initially in each eye separately, and then in both eyes. **Squinting is not permitted**. After the uncorrected vision is tested the corrected vision should be tested in the same manner.

Contact Lens Wearers –It is necessary to test the uncorrected vision in the initial examination without the use of lenses or provide a contact lens report from an eye care professional. They should also be tested with backup glasses prior to putting their lenses in place and the results noted beside the distant vision testing blocks.

If a contact lens wearer cannot remove his/her lenses at the initial examination, he/she should be required to return. It is not necessary at repeat examinations to remove the contact lenses.

In initial applicants if the uncorrected vision is 6/60 or less the refractive error must be recorded in the space provided.

Be sure to note whether contact lenses were worn during the examination and whether you recommend an eye specialist's examination.

FIGURE 3

VISION STANDARDS

	In each eye separately, equal or better than
Distant Vision	
Category 1	6/9 (20/30) Corrected or uncorrected. No less than 6/60 (20/200) uncorrected unless the Equivalent Spherical Error (ESE) is less than ± 3.50 Dioptres.
Category 2	Same as Category 1.
Category 3	6/9 (20/30) Corrected or uncorrected. No less than 6/60 (20/200) uncorrected unless the ESE is less than ± 5.00 Dioptres.
Category 4	No less than 6/9 (20/30) in the better eye.
Near Vision	
Categories 1, 2 and 3	N5 at 30 - 50 cm.
Category 4	No standard.
Ocular Muscle Balance	
Categories 1, 2 and 3	Exophoria and Esophoria: maximum 6 prism diopters. Hyperphoria: 1 prism dioptre.
Category 4	No standard.

N.B. Vision Testing machines such as the Titmus Vision Tester, Keystone Orthoscope or Telebinocular, Bausch & Lomb Orthorator may be used.

Near Vision

Near vision should be tested with the *Faculty of Ophthalmologists Reading Type 'N'* charts or equivalent. Vision in each eye separately should be tested without and then with correction. Use good "over the shoulder" illumination of the card and avoid reflections and glare. Note that the standard does not require the near vision correction to meet TC Standards in each eye separately.

Ocular Muscle Balance

Ocular muscle balance can be tested with the cover test, the Maddox rod or an approved vision tester. Report the results of the cover test in the space provided. The Maddox rod results should be noted in the appropriate spaces. Checking the orthophoria box means that there is no deviation and the other spaces can be left blank. Any deviations should be noted in the esophoria, exophoria and hyper phoria boxes.

Maddox Rod Test – This is described in detail in Appendix 1 and on the aviation vision video. The results should be recorded in the number of diopters of esophoria, etc. The use of this instrument is demonstrated in the video *The Vision Examination for Aviation Medical Examiners*.

Cover Test – The purpose of this test is to determine whether manifest strabismus is present, or whether there is any tendency of the eyes to deviate when the two eyes are dissociated. The examiner stands in front of the candidate who is told to fix his eyes on a small target such as a small examining light. An occluder card is then placed in front of one eye and the other eye checked for movement. If there is none the card is removed and the covered eye examined to see whether it has remained fixed or whether it has moved medially or laterally and has to be re-fixated. The test is then repeated with the other eye covered.

If the candidate is orthophoric no movement of the eyes will take place. If there is esophoria one eye will move in and then re-fixate when the occluder is removed. In exophoria the opposite is true. **It should be noted that less than 10% of individuals are orthophoric!**

Colour Perception

Colour perception should be tested at each aviation medical examination because various eye diseases may cause a change or deterioration. Colour vision may be tested with any of the standard pseudo-isochromatic test plate sets noted in Appendix 2.

Appropriate lighting must be provided for testing. If a special colour balanced light source is not used, daylight is best for screening. Be wary of fluorescent or incandescent lights which may cause inaccurate readings. The type of plates (Ishihara etc.), the number of plates in the set (versus the number that should be used for testing) and the number of errors should be noted.

An applicant failing colour plate testing may have a colour lantern or a Farnsworth D-15 Hue test performed. These tests are available at a number of locations across the country or CAM regional offices.

Note: The colour lantern test is not acceptable for initial air traffic controller applicants, who must pass the plates or a Farnsworth D-15 Hue test.

Hearing Examination

This should be tested with the whispered voice. The applicant must be able to hear and understand at a distance greater than 2 metres. Testing with screening audioscope is acceptable. Abnormalities noted on the screening test should prompt testing by pure tone audiometry. Candidates for Category 1 or 2 medical certification will require a pure tone audiogram at the initial examination.

Urinalysis

Routine dip-stick testing of the urine for glucose is required at each aviation medical examination. Microscopic examination is only required where clinically indicated.

Other tests

– Self-explanatory.

Renewing a Medical Certificate

If an applicant who has a Medical Certificate (MC) meets all the medical standards in CAR 424 you may renew it by stamping and signing one of the renewal boxes A,B,C or D on the back of the MC. Also fill out the ECG box if an ECG was done. This document then becomes the renewed MC. **You** cannot **grant additional privileges**. For example, if an applicant with a restriction such as "Valid only when wearing required glasses" presents for medical certification with contact lenses, you can only extend the present privileges, not give authorization for him/her to use contact lenses when flying. This must be done by CAM. In the same way you cannot give authorization for an upgrade from one medical category to another.

Initial applicants do not have a MC so you cannot grant them a medical category and can only mark the DEFERRED box, indicating "initial applicant" under the remarks area.

If an applicant does not present a MC for signature you cannot renew, but only mark DEFER and indiate "no MC available" under the remarks area.

If an applicant wishes to upgrade from a Category 3 to Category 1, complete the examination, arrange for an ECG and audiogram to be submitted with the MER, and renew the existing Cat 3 MC for the full period. If the applicant meets the Category 1 standard then a new multi sign off Category 1 MC will be sent to him\her by Transport Canada.

If renewal has been granted, mark "yes" in the "Was a renewal assigned" block on the MER. If it was not granted mark "no", check the DEFERRED box, and indicate the reason in the space underneath. Also indicate whether further examination is recommended and whether a separate confidential report is being submitted.

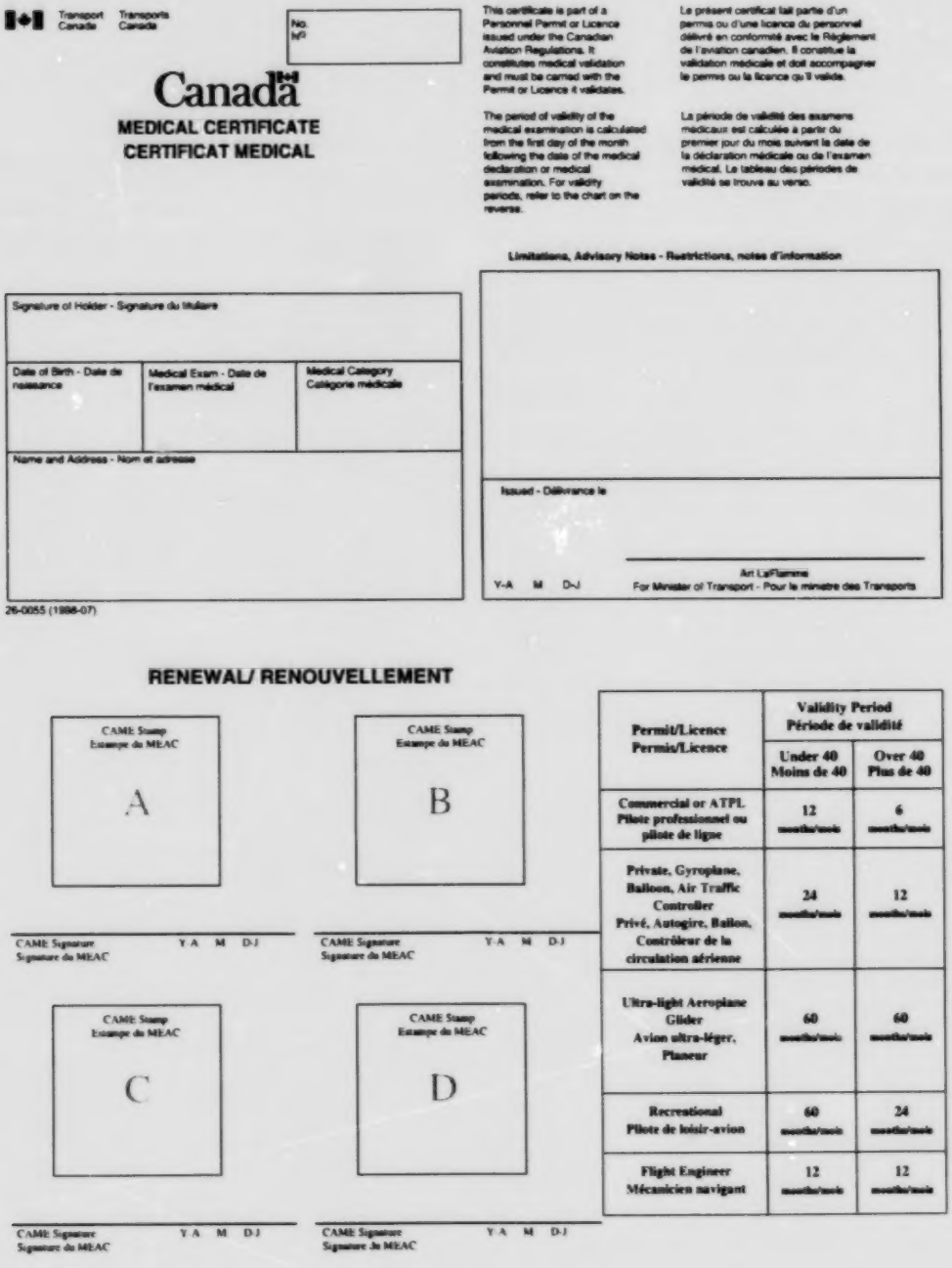
Note: If you do not believe an applicant is fit for the category requested, DO NOT RENEW THE MC, mark the DEFERRED box in part "D" of the MER, and add your comments, either in the remarks section or in a confidential report.

The examination form and all additional test results are then forwarded to the RAMO. A copy should be retained in your office for a minimum of six months, but it is wise to retain the copies indefinitely as with any medical record, particularly in the present climate of medico-legal litigation.

Special Renewal

A small number of licensed personnel will have been issued with a MC that has been endorsed over the renewal boxes "Not valid for CAME renewal".

In these cases, send in the medical examination report and any other reports/tests that have been requested. Mark the "depressed" box in Part "D". The applicant will be issued with a new MC at each examination.



Transport Canada / Transports Canada

No. / N°

Canada

MEDICAL CERTIFICATE
CERTIFICAT MEDICAL

This certificate is part of a Personnel Permit or Licence issued under the Canadian Aviation Regulations. It constitutes medical validation and must be carried with the Permit or Licence it validates.

The period of validity of the medical examination is calculated from the first day of the month following the date of the medical declaration or medical examination. For validity periods, refer to the chart on the reverse.

Le présent certificat fait partie d'un permis ou d'une licence du personnel délivré en conformité avec le Règlement de l'aviation canadien. Il constitue la validation médicale et doit accompagner le permis ou la licence qu'il valide.

La période de validité des examens médicaux est calculée à partir du premier jour du mois suivant la date de la déclaration médicale ou de l'examen médical. Le tableau des périodes de validité se trouve au verso.

Limitations, Advisory Notes - Restrictions, notes d'information

Signature of Holder - Signature du titulaire

Date of Birth - Date de naissance

Medical Exam - Date de l'examen médical

Medical Category Catégorie médicale

Name and Address - Nom et adresse

Issued - Délivrance le

Y-A M D-J

Art LaFlamme
For Minister of Transport - Pour le ministre des Transports

26-0055 (1998-07)

RENEWAL/ RENOUVELLEMENT

CAME Stamp
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A

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D

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Permit/Licence Permis/Licence	Validity Period Période de validité	
	Under 40 Moins de 40	Over 40 Plus de 40
Commercial or ATPL Pilote professionnel ou pilote de ligne	12 months/mois	6 months/mois
Private, Gyroplane, Balloon, Air Traffic Controller Privé, Autogire, Ballon, Contrôleur de la circulation aérienne	24 months/mois	12 months/mois
Ultra-light Aeroplane Glider Avion ultra-léger, Planeur	60 months/mois	60 months/mois
Recreational Pilote de loisir-avion	60 months/mois	24 months/mois
Flight Engineer Mécanicien navigant	12 months/mois	12 months/mois

FIGURE 3

Medical Certificate Form

APPENDIX 1

THE MADDOX ROD TEST

This test is used to uncover latent squints (phorias). The test may be performed with a handframe, a vision tester or a trial frame but the principle in all is the same. If a candidate is given two dissimilar targets to view at the same time, the stimulus to fusion is absent and phorias are uncovered.

The Maddox rod is a disc of red glass in which are molded grooves. When a distant spot of light is viewed with the disc in front of one eye, a red line will be seen by the eye covered with the lens, whilst a spot of light will be seen with the other eye. The line will be at right angles to the grooves to that when these are horizontal the line will appear vertical. A candidate with no latent deviation will see the coloured line pass through the spot of light (orthophoria), whereas a candidate with latent squint will see the light source to one side of the line.

The Maddox rod with rotating prism is held in front of the right eye and the candidate is asked to look at a point source of light 6m (20 ft.) away in a darkened room. Both eyes must be open and squinting should be avoided. The candidate is asked which side of the line the dot is seen. If it is to his right, esophoria is present and if to the left, exophoria. The candidate is then asked to "put the line on the light" by adjusting the rotating prism. The examiner reads off the degree of phoria from the scale on the device.

The test is repeated with the disc turned to the vertical position. The light will now be seen either above or below the line and may be adjusted by the candidate in the same way. If the red line is above the light there is left hyperphoria, if below the light, right hyperphoria.

If the candidate sees several lines, there are aberrant light sources and, if they cannot be suppressed, the correct line can be indicated by turning the spot light on and off several times. Some candidates are aware that the line should pass through the spot and may try to hide their phorias. This should be suspected if a candidate with an abnormal cover test sees the line directly through the light. In this case the lens can be adjusted so the dot and the line do not coincide and the candidate's response should be noted.

Definitions

Orthophoria – No tendency to deviate.

Esophoria – Tendency of the eye to turn in.

Exophoria – Tendency of the eye to turn out.

Hyperphoria – Tendency of one eye to turn up or the other eye to turn down.

Demonstrations of the Maddox rod Test may be seen on the video *The Vision Examination for Aviation Medical Examiners*.

APPENDIX 2

COLOUR VISION

In the retina there are two groups of photosensitive cells, the rods and the cones. The cones, concentrated in the central retina, are colour sensitive. They contain three different pigments. One is sensitive to red, another to green and a third to blue. Congenital colour deficiencies are caused either by the absence of one of the pigments or by an alteration in the pigment which leads to distortion of colours. People lacking or deficient in the red pigment are known as Protans, the green pigment Deutans and the blue pigment Tritans. The latter problem is unimportant and unusual.

Normal people are trichromats. Those who have only two pigments are dichromats and, according to the missing pigment, are referred to as protanopes, deuteranopes and tritanopes. There are also groups of trichromats whose pigments, although present, are anomalous. According to the pigment therefore they are protanomalous, deuteranomalous or tritanomalous (trichromats). Approximately 8.5% of the male population and 0.4% of the female population have colour vision defects. About 4.6% of all males are deuteranomalous trichromats and the other 3.4% are evenly distributed amongst the protanomalous trichromats, deuteranopes and protanopes with a frequency of about 1% each.

Pseudoisochromatic plate tests differentiate between people with normal colour vision and those with defective colour vision of types which might interfere with aviation safety. These plates should be viewed by the applicant in *natural daylight*. The applicant should not be allowed to wear sunglasses or *X-Chrom* lenses. Each plate should be held approximately 75 cm. in front of the applicant with the plate perpendicular to the visual line. A delay of up to three seconds is allowed for the answer to each plate and it is permissible to repeat a plate if the patient has a negative response. If two responses are given, the second should be recorded. The plates should be given in a random order so they cannot be memorized. The number of acceptable incorrect responses to each type of plate is shown below. Colour vision testing should be carried out from time to time as it also varies in eye diseases and may be an early method of detecting such problems.

Applicants who fail the plates may be tested with a colour vision lantern. A number of these are available in each region and information is available through the RAMO's office. The Farnsworth D-15 Hue test is also acceptable.

Note: The colour lantern test is not acceptable for initial air traffic controller applicants, who must pass the plates or a Farnsworth D-15 Hue test.

TYPE	EDITION	TESTED	ERRORS ALLOWED
American Optical (1965 Ed.)	18	1-18	3
Ishihara	16	1-8	1
Ishihara	24	1-15	2
Ishihara	38	1-21	3
American Optical HRR	20	1-6	0
Titmus		All	0
Keystone Orthoscope		All	0
Keystone Telebinocular		All	0
Ishihara (concise)	14	1-14	Special explanation with plates

SECTION 2

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SECTION 2

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THE ATMOSPHERE

The earth's atmosphere surrounds it like a gaseous blanket, kept in place by the gravitational field. The depth of the atmosphere varies from time to time, being greater in the summer than in the winter and greater at the lower latitudes than at the higher latitudes. Heat radiating from the sun causes atmospheric gases to expand into space and it is the interaction between this force and gravity that sets the limits of the atmosphere.

Composition

The atmosphere is a mixture of various gases. The three of greatest importance are Nitrogen (78.09%), Oxygen (20.95%) and Carbon Dioxide (0.03%). The remainder is made up of rare gases. The composition of the atmosphere is remarkably constant up to approximately 300,000 feet although at high altitudes the distance between gas molecules becomes progressively greater and collisions between particles becomes rarer. There is a variable amount of water vapour in the atmosphere up to about 30,000 ft. and in the lower altitudes there are also solid pollutants which provide nuclei for condensation.

Divisions

We live in the troposphere which means "the area of change". In the troposphere the temperature decreases with increasing altitude at a rate of 1.98°C or 3°F/1000 ft. The troposphere extends up to 60,000 ft. over the equator but only to about 30,000 ft. over the poles. At that altitude it becomes the tropopause where the air temperature is fairly constant between -50 and -55°C. Above the tropopause, which is about 30,000 ft. deep, is the stratosphere which extends to about 50 miles (80 kms.). There is no weather in the stratosphere and indeed there is little weather above 35,000 ft. One of the joys of flying is that on the dullest day one can break out into bright sunlight if you climb high enough.

Ozone

Within the stratosphere lies the ozonosphere at 18-30 miles (30-50 km.) above the earth. The temperature here becomes warmer (about 35°C) due to heat released when ozone is converted to oxygen by solar radiation. Only in the last decade has the importance of the ozone layer become apparent to us all. In the stratosphere oxygen absorbs ultraviolet (UV) radiation of 2,000 Å. And 3 molecules of oxygen are transformed into 2 molecules of ozone. If unchecked this reaction would produce a huge amount of ozone, however ozone in turn absorbs ultraviolet light from 2,100 to 2,900 Å. and is converted back to oxygen. This balanced reaction results in the almost total absorption of harmful ultraviolet radiation. Recently it has been found that the ozone layer is being destroyed, particularly over the poles, by earth's pollutants. This may give rise to the increasing penetration of UV light causing an increase in skin cancer, cataracts and other health problems.

Ozone is a blue, unstable, toxic gas. The concentration at ground level is 0.03 parts per million (ppm) by volume but this increases rapidly above 40,000 ft. to become a maximum of 10 parts per million by volume at 100,000 ft. Modern supersonic aircraft fly at altitudes where this can be a problem. In the human, acute exposure for two hours to between 0.6 and 0.8 ppm. reduces the diffusing capacity of the lungs and slightly reduces vital capacity and forced expiratory volume. Fortunately these effects are not permanent unless there is continual exposure. Ozone impairs night vision in man and in human cell cultures can induce chromatic breakages identical to those produced by x-rays. Fortunately ozone is thermally unstable and is decomposed promptly to oxygen at 400°C. This temperature is reached by the Concorde's air conditioning compressor circuit during climb and cruise, neutralizing what could otherwise be a significant problem.

Atmospheric Pressure

Atmospheric pressure is the weight of the gases surrounding the earth. It is a function of height, density and the force of gravity. At ground level it is recorded by meteorologists as 101.32 kilopascals but many people prefer the older 14.7 lbs. per sq. inch or, as used in most medical calculations, 760 mmHg. of mercury. Atmospheric pressure decreases with altitude and at 18,000 ft. it is halved (380 mmHg) and at 33,000 ft. quartered. It should be noted that the changes are small and gradual compared to the changes observed going down in water. Here atmospheric pressure doubles at 33 ft! As will be noted later this is a point of importance when dealing with fliers who are also scuba divers.

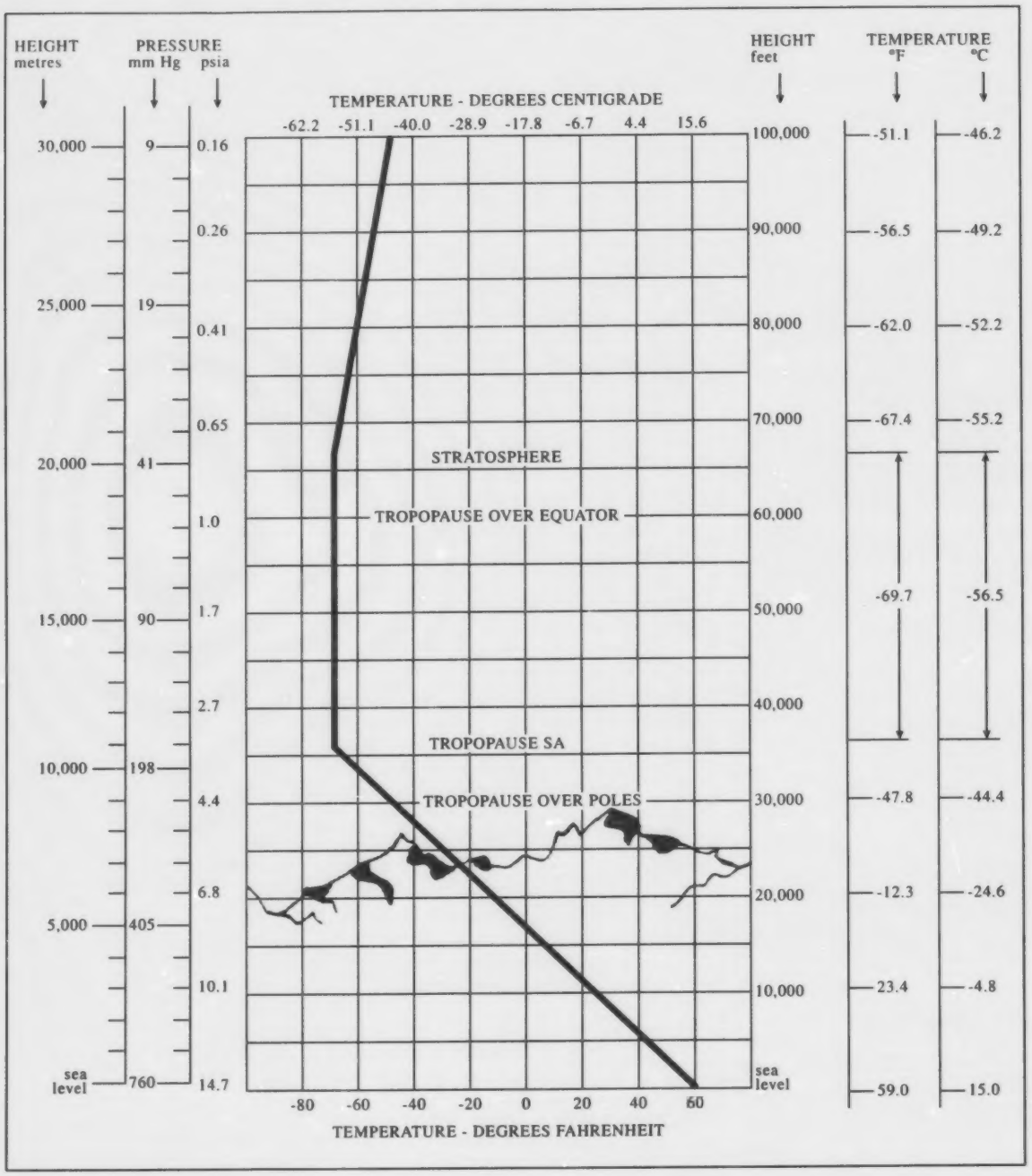

FIGURE 5

The properties of the standard atmosphere showing the variation in the height of the tropopause.

Cosmic Radiation

The atmosphere is affected by both galactic and solar ionizing radiation. The former is a predictable, low density flux of high energy particles from outside the solar system. Most of these are deflected by the earth's magnetic field although the protection is greater in the equatorial regions than at the poles. There is also some protection by the solar inter-planetary magnetic field and by the stratospheric absorption of low energy particles. Measurements of this type of radiation have been taken from high altitude aircraft. Fortunately the annual dose is relatively low in constantly exposed air crew. Solar radiation is of lower energy but its production may be intense and is generally unpredictable although it appears to reach a peak about every 11 years. The earth is well shielded by its atmosphere but the dose may be significant in prolonged high altitude or space flight. It's most commonly observed effect is interference with radio and other forms of communication equipment at the time of solar flares. Space flight will lead to more precise measurements of its long term effects.

HYPOXIA AND HYPERVENTILATION

The hazards of high altitude became evident as soon as men set out in balloons, although the dangers had been suspected by missionaries in mountainous areas long before. In 1590 the Jesuit Priest Acosta noted "... I am convinced that the element of the air is in this place so thin and so delicate that it is not proportioned to human breathing which requires extensive and more temperate air".

In 1862 Glaisher and Coxwell made an ascent by balloon to almost 29,000 ft. and became unconscious. Fortunately one of them, his hands frozen, was able to raise his head sufficiently to grab the valve cord of the balloon in his teeth before passing out, thus releasing hydrogen and bringing the balloon back down. Paul Bert in the late 1860's built an altitude chamber and reached the conclusion that, regardless of barometric pressure, air could not supply life when the partial pressure of oxygen reached 45 mm. Hg. In April of 1875 Crocé-Spinelli, Sivel and Tissandier made the first flight in a balloon using oxygen although Bert had warned them the supply was far too small. Only one of the three survived, the other two dying of hypoxia.

Respiratory Physiology

To maintain life, oxygen has to be inhaled, diffused across the alveolar-capillary membrane, carried by hemoglobin to the tissues and then transferred to the individual cells for aerobic metabolism. Dalton's Law states that the partial pressure of a gas in a gas mixture is equal to the pressure which the gas would exert if it alone occupied the space taken up by the mixture. Each of the gas components in the mixture therefore exerts pressure proportional to the fraction which it represents. Oxygen, being present as 20.9%, (21%) of the gases in our atmosphere exerts a partial pressure of 160 mm. Hg in dry air at sea level. However this changes when it is inspired. In the nasopharynx air is exposed to water vapor and becomes saturated at body temperature (37°C). Water vapour pressure is 47 mm. Hg. In the trachea therefore the partial pressure of oxygen will be (760 - 47) x 0.21 or approximately 150 mm. Hg. Passing from the trachea to the alveolus, oxygen becomes mixed with carbon dioxide. It is also diffusing into the tissues from the respiratory bronchioles down, so by the time the alveolus is reached, the partial pressure of oxygen is much lower. The partial pressure of carbon dioxide is about 40 mm. Hg so the alveolar partial pressure of oxygen at ground level, when the respiratory quotient is taken into account, is 103 mm. Hg (For those mathematically inclined relevant formulas are given at the end of this chapter). This steadily dropping partial pressure is known as the respiratory cascade.

The diffusion of oxygen (and of carbon dioxide in the opposite direction) takes place at the level of the respiratory bronchioles and below. The majority of the diffusion takes place at the alveolus which is virtually surrounded by capillary blood. The area of the alveolar-capillary interface is astonishingly large, between 90 and 100 sq. metres. If spread out the alveoli would cover a double tennis court.

Diffusion at the alveolus takes place along the pressure gradient with most of the oxygen being picked up by hemoglobin for transfer to the tissues. The rate of diffusion of a gas is proportional to its solubility and to the pressure gradient. Carbon dioxide, being more soluble than oxygen, diffuses at a faster rate. In the tissues the pressure of oxygen falls with increasing distance from the capillary, with the lowest level being found midway between two capillaries. If the partial pressure of oxygen falls below 3 mm. Hg in the tissues anaerobic metabolism develops. Under normal conditions a rise in $PC0_2$ and the formation of tissue lactic acid causes capillaries to dilate. In muscle the number of open capillaries can increase by 200 times but in the brain most of the capillaries are open, even at rest, so even in the face of imminent hypoxia the number of cerebral capillaries can increase only by a factor of four. This is why hypoxia affects the brain first.

Hemoglobin Dissociation

Oxy-hemoglobin (Hb0) dissociation describes an S-shaped curve (See figure 6) when saturation is plotted against oxygen partial pressures. The characteristics of this curve are important. Down to a partial pressure of 60 mm., saturation remains above 90%. Below this point saturation drops off rapidly being less than 80% by the time the partial pressure has dropped to 45 mm. The sharp drop-off of the curve enables oxy-hemoglobin to unload rapidly in the relatively hypoxic tissues and equally allows reduced Hb to pick up oxygen rapidly at normal diffusion gradients. Under hypoxic conditions lactic acid is formed in the tissues causing a relative acidosis

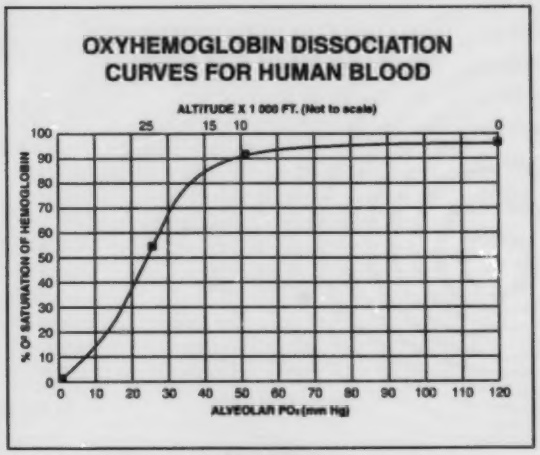

FIGURE 6

which moves the curve to the right, increasing the uptake and release of oxygen. In alkalosis, as in hyperventilation, the curve moves left, lessening tissue availability. (Fig.6)

At 10,000 ft. the PAO2 has reached 60 mm., which is the beginning of the rapid drop in hemoglobin saturation. Above this altitude significant tissue hypoxia develops and it is for this reason that oxygen is required while flying above 10,000 ft. If the pilot is breathing 100% oxygen however the partial pressure of oxygen at any level will be much higher. The critical level of 60 mm. at the alveolus for example will not be reached until 40,000 ft. This is referred to as an "equivalent oxygen level".

Hypoxia

Hypoxia is an insidious killer. There is a tendency for euphoria to develop while motor skills and reasoning abilities deteriorate. The result is that in many cases the pilot may become seriously hypoxic without appreciating that there is a problem. To the observer tachypnea, cyanosis, mental confusion and loss of muscle coordination are obvious. To the pilot however, the only symptoms may be slight dyspnea, dizziness, fatigue, decreasing vision and finally loss of muscular control. Night vision can be impaired at as low as 5000 ft. Tolerance to hypoxia varies from individual to individual and from time to time. Tolerance can be increased by continual exposure to high altitudes and varies with the level of the hemoglobin and the oxygen carrying capacity of the blood. It is decreased by fatigue, cold and poor physical conditioning. Even at 5,000 ft. night vision is decreased.

Types

Hypoxia is generally divided into four types. *Hypoxic hypoxia* is due to a decrease in the oxygen available to the body such as typically occurs with altitude. *Hypemic hypoxia* is caused by a reduction in the oxygen carrying capacity of the blood for any reason. It also occurs when hemoglobin is saturated by gases for which it has a higher affinity, the most common of which is carbon monoxide. This is not only produced by exhaust leaks into the cockpit but also by *cigarette smoking*. Carbon monoxide is a product of incomplete combustion and may be present at levels of 6-8% in the blood of a heavy smoker and such individuals may become significantly hypoxic at levels below 10,000 ft.

Stagnant hypoxia is a less common problem caused by a reduction in total cardiac output, pooling of the blood or restriction of blood flow. Heart failure, shock, continuous positive pressure breathing and G-forces in flight can create stagnant hypoxia. Local stagnant hypoxia can occur with tight and restrictive clothing or, in the cerebral circulation, in association with vasoconstriction due to respiratory alkalosis provoked by hyperventilation.

Histotoxic hypoxia refers to poisoning of the respiratory cytochrome system by chemicals such as cyanide or carbon monoxide but it can also be caused by the effects of alcohol. Needless to say a pilot in poor physical condition, recovering from a hangover and smoking while in flight can quickly become an unfortunate statistic!

Gravity and Atelectasis

In the seated position the lungs, due to the pull of gravity, are stretched at the apices and condensed at the bases. At the same time, the blood supply is least at the apices and greatest at the bases. Thus in the area where the alveolar ventilation is best, perfusion is least and at the bases the opposite is true. Only in the mid section of the lung is there an ideal ventilation - perfusion ratio. Under positive G, the situation is exaggerated and if it is of long duration in crews breathing oxygen, rapid absorption from the alveoli tends to cause basilar atelectasis.

HYPERVENTILATION

Hyperventilation may be described as a respiratory rate excessive for the body's oxygen requirements. It may be voluntary or involuntary and can occur in relation to many different activities. In the pilot the most common precipitating causes are anxiety, fear, excessive concentration on a flight procedure and as a reaction to pain or illness. Hyperventilation may be obvious, as in the case of children preparing to compete in underwater swimming, or it may be covert as for example when the respiratory rate increases from a required 12 per minute to an excessive 15 per minute and remains elevated for a prolonged time.

Whatever the cause the results are the same. Carbon dioxide, the most potent stimulus to respiration, is blown off in excessive amounts. The PaCO2 falls and respiratory alkalosis develops. The cerebral vessels become constricted and subjectively the pilot often notices a feeling of dizziness, a coldness and tingling around the lips and a feeling as though there was a band around the head. Nausea may be present. Peripherally there is vasodilatation and stimulation of sensory nerves causing a sensation of pins and needles in the hands and in the feet. If hyperventilation continues carpopedal spasm develops and the subject may become unconscious and develop frank tetany. With the breath held the carbon dioxide levels build up once more and the symptoms disappear in reverse order.

Obviously such a chain of events can lead to an accident. This has been documented in some incidents in young fighter pilots or untrained private pilots who have inadvertently flown into bad weather and have kept the microphone button depressed, broadcasting their breath patterns up to their final moment. Hyperventilation is often suspected in unexplained accidents. If one considers the symptoms of hypoxia and hyperventilation it will be seen that they are very similar. As it is imperative in the air that no mistake be made, the treatment for both is to breathe oxygen and to reduce the rate and depth of respiration.

Pressurization and Depressurization

Although it is usually in military pilots that problems arise with hypoxia at levels above 30,000 ft., it must be remembered that more and more commercial aircraft are now cruising at extreme altitudes and flight above 40,000 ft. is common. The Concorde, for example, cruises above 60,000 ft. Cabin pressurization in these aircraft ensures that the partial pressure of oxygen is adequate and it is rare for the cabin pressure to be above 7,000 ft. (See Fig. 7). However, it is wise to remember that passengers with chronic lung diseases or serious anemia, particularly those who are smokers, may be significantly hypoxic even at this altitude.

Figure 7

CABIN PRESSURIZATION

Ambient Altitude in feet	*Cessna 152*	*Boeing 727*	*Boeing 777*	*Boeing 747*
80,000	-	-	-	-
40,000	-	-	6,500	7,700
35,000	-	5,500	4,500	4,700
22,500	-	SL	SL	SL
15,000	15,000	SL	SL	SL
SL	SL	SL	SL	SL

SL = Sea Level

More dangerous however is the situation which develops when cabin pressure suddenly fails, usually due to the loss of a window or door. The result is *rapid decompression* with a sudden increase in the cabin altitude to match the ambient altitude. In aircraft such as the Concorde the windows have been made particularly small to lessen this effect but in older aircraft more serious problems have occurred. The immediate effect of decompression is a loud noise, condensation of water vapour causing a mist and a shower of dust and small particles. The temperature falls dramatically. The resultant cabin pressure may actually fall below that of the ambient pressure due to "*aerodynamic suck*". This refers to the Venturi effect created by the speed of the aircraft through the air.

The initial hazard to aircraft safety is hypoxia. The crew are unlikely to be wearing oxygen masks at the time of the incident and, if the final cabin altitude is high, the time of useful consciousness may be very short (see Figure 8). It may actually be lower than would be anticipated because of the sudden escape of expanding gas from the lungs due to the reduced ambient pressure. This causes reversal of the oxygen diffusion gradient across the alveolar membrane and oxygen passes back into the lung from the blood. At

Figure 8

TIMES OF USEFUL CONSCIOUSNESS
(Effective performance time)

Altitude	*Conscious time*
20,000	5-12 minutes
25,000	2-3 minutes
30,000	45-75 seconds
35,000	30-60 seconds
40,000	10-30 seconds
45,000	12-15 seconds
50,000+	12 or less seconds

35,000 ft. the time of useful consciousness is generally quoted as 30-60 seconds but at altitudes of above 40,000 ft. this may be reduced to 12-15 seconds, the normal circulation time. Airlines make provision for this eventually by providing pilots with "quick-donning" oxygen masks, which can be donned in 5 seconds or less.

FOR THOSE OF MATHEMATICAL BENT

In Dry Air:

PIO2 = AP x FIO2 where PIO2 is the partial pressure of oxygen, AP is atmospheric pressure and FIO2 is the fraction of oxygen in the inspired air.

In the Trachea:

PIo2 = (AP - WVP) x FIo2 where WVP is water vapour pressure. At sea level this is (760 - 47) x 0.21 = 150 mmHg.

In the Alveolus:

PAo2 = PIo2 - PACo2 (FIo2 + (1 - FIo2/R)) where PACo2 is the partial pressure of carbon dioxide and R is the respiratory quotient.

Therefore at sea level PAo2 = 150 - 40 (0.21 + (1-0.21/0.82)) = 103 mmHg.

Or at 18,000 ft. = (380 - 47) x 0.21 - 30 (0.21 + 1 - 0.21/0.82) = 35 mmHg.

The respiratory quotient (R) on a pure carbohydrate diet is 1.00, on a protein diet 0.81 and on an animal fat diet 0.71. On a balanced diet of carbohydrate, protein and fat, R is generally about 0.83.

DYSBARISMS AND ALTITUDE SICKNESS

We have already commented on the decrease in atmospheric pressure which occurs with altitude. Boyle's Law states that, at constant temperature, the volume of a gas varies inversely with the pressure. If the pressure of gas is halved, its volume is doubled. Application of this simple law to the closed body cavities quickly indicates where problems are likely to occur.

Barotitis

By far the most common problems are with the middle ear. It resembles a box, closed by a flexible diaphram at one end and drained by the Eustachian tube narrow tube at the other. The eustachian tube however is not rigid or symmetrical throughout its length and becomes slit-like at its outlet in the nasopharnyx. On ascent expanding trapped air usually escapes easily and the only thing noticed is a periodic "popping" due to movements of the drum as pressure equalizes. On descent however equalization of pressure through the slit-like outlet is much more difficult and a negative pressure can build up in the middle ear. This leads to a decrease in hearing and to pain. The ear can be cleared by opening and closing the mouth, thus activating the tensor tympani muscle and dilating the tube, or by inflation by a Valsalva manoeuvre. In an U.R.I. or other pathology of the nasopharynx, congestion of the outlet makes clearing more difficult or even impossible. The pressure in the middle ear on descent may then become so low relative to the outside pressure that exudation and hemorrhage may take place and ultimately the eardrum may burst. Excessive valsalva maneuvers however may force bacteria into the middle ear, leading to infection.

When an ear blocks and cannot be cleared by the usual maneuvers, the best way to deal with the situation is to reascend and start a slower descent. This is not always possible. During World War II the pilots of vertical diving Stukas had constant ear problems and their flight surgeons solved these by periodically incising the drums! Nowadays this is not recommended! A particular problem occurs when pilots flying at high altitude on oxygen retire to sleep soon after landing. The middle ear is full of soluble oxygen (rather than inert introgen) which is absorbed during sleep. On awakening they have earache due to the indrawn drums. This is called "*oxygen ear*".

Other Barotraumas

Other air spaces are equally affected. The nasal sinuses are a common source of pain as may be poorly filled teeth if the filling has not been carefully inserted and a gas space remains below it. These various symptoms are referred to as "barotraumas" and toothache of this type is known as "barodontalgia". The best approach to these conditions is knowledge and prevention. Fortunately most professional pilots are well aware of the problems and avoid flying when they are congested.

Intestinal Gas

A common irritating, embarrassing and potentially serious problem is gas in the bowel. This expands rapidly as might be expected and, if it cannot be passed, may lead to severe pain. Chewing gum, air swallowing, carbonated drinks and beer (in the passenger) all add to the gas, as do various gas producing foods. Passengers with ostomy bags or various types of bowel obstruction are particularly likely to have problems.

Inflatable Medical Aids

Boyle's Law must be kept in mind if you are involved in the transport by air of patients requiring cuffed tubes of any type or if casts or pneumatic dressings are being used. Cuffs should be inflated with saline (or water) rather than air before the trip.

DECOMPRESSION SICKNESS

The "Bends" or "Caisson disease" has been recognized since 1841 in association with "hard hat" divers or men working under pressurized conditions. By the end of WWI the possibility of decompression sickness in aviators was predicted and once high altitude balloon flights were undertaken the prediction was fulfilled. The cause of decompression sickness is the formation of gas bubbles in the body and the physical law was described by Henry. Henry's Law states that the quantity of gas that goes into solution at a given temperature is dependent upon its solubility characteristics and is proportional to the partial pressure of that gas over the surface of the liquid. Hence as the pressure falls, the amount of gas which can be held in solution is reduced.

Bubble Formation

The dominant gas in the atmosphere we breathe is nitrogen. It is inert and the body is saturated with it at sea level. During rapid ascent the reduction of barometric pressure creates a condition whereby the inert gas tension in the tissues is greater than the external barometric pressure. This condition is called super-saturation. At this point, in association with bubble nuclei produced by muscle shear forces or turbulent blood flow, bubbles of nitrogen can be formed in the tissues and in the body fluids. It is these bubbles which give rise to decompression sickness.

Symptoms

The symptoms of decompression sickness are described as the four "C's". These are Creeps, Cramps, Chokes and Collapse". "*Creeps*" is an unpleasant sensation as though tiny insects are moving underneath the skin. This "formication" is believed to be caused by the formation of tiny bubbles. "*Cramps*", usually described as "Bends", are manifested by pain which tends to be localized in and around the large joints of the body. Smaller joints may be affected and it is not uncommon to first notice the symptoms in joints which have previously been injured. The pain is deep and aching in character and varies from mild to severe. It is made worse by movement of the joints and is sometimes improved by pressure on the area. "*Chokes*" are rare, occurring in less than 2% of cases. It is a much more serious disorder caused by multiple pulmonary gas emboli. The subject complains of substernal chest pain, dyspnea and a dry, non-productive cough. He/she feels ill and usually appears anxious and distressed. If altitude is maintained "*Collapse*" will inevitably occur. The treatment is immediate descent which is generally effective.

Neurological Effects

Neurological decompression sickness is the most dangerous form and often has a very serious prognosis. It may be responsible for permanent neurological deficits particularly if hyperbaric treatment is not immediately available. It occurs in 5-7% of cases of decompression sickness, and, in altitude cases not relieved by returning to ground level, the central nervous system is involved 35-50% of the time. In the aviator brain injuries, although uncommon, are most frequent. In divers the spinal cord type is most frequent. The reason for this variance is not known.

In the brain type visual disturbances (scotoma, tunnel vision, diplopia etc.) are common together with headache and confusion. Physical signs are spotty and diffuse, both motor and sensory. The signs may be thought to be hysterical but collapse may occur. In the spinal cord the most common onset is of numbness or paraesthesia in the feet. This tends to spread upwards in the cord with ascending weakness and/or paralysis. A complete transverse spinal cord lesion may occur as bubbles obstruct the blood supply and infarct the cord.

Fortunately serious decompression sickness is uncommon in commercial aviation. Generally the altitude threshold is above 18,000 ft. although it rarely occurs below 25,000 ft. Above 26,000 ft. it is more common. It is much more often seen therefore in high altitude military pilots whose cockpit pressurization profiles are lower than those in commercial aircraft.

Provocative Factors

There are various factors which affect it. The incidence increases with age, there being a threefold increase between the 19-25 year old and the 40-45 year old age groups. Nitrogen is well dissolved in fat, so obesity is a factor. It is probably more common in

women than men. It is more common with exercise at altitude, with rapid ascents, with re-exposure to altitude at frequent intervals and at low temperatures. The after effects of alcohol and intercurrent infection both increase the susceptibility.

Scuba Diving

It is important to keep in mind the relationship between scuba diving and decompression sickness in aviators. Scuba divers use compressed air in their tanks and are often exposed to two or more atmospheres of pressure, supersaturating the tissues. If they fly within twelve hours of emerging from diving at standard depths, decompression sickness has been recorded at altitudes as low as 10,000 ft. Where they have been diving at depths which require decompression stops on the way to the surface, they should not fly for a minimum of 48 hours. Although serious problems are uncommon, it is necessary to be aware of the danger to recognize it, particularly with neurological symptoms.

Occasionally a medical emergency results when a diver ascends to the surface too rapidly, causing bubble formation. In such cases the diver must be re-exposed to a greater pressure as quickly as possible and then brought back to the surface. Sometimes the diver is too ill to undertake another dive and must be transported to a hyperbaric chamber for treatment as quickly as possible. Pilots transporting such individuals should be cautioned that increases in altitude will worsen the patient's condition. If pressurized aircraft are not available, flights should be made at the lowest safe altitude. Recompression treatment tables are outlined in textbooks of diving medicine.

ACCELERATION

Doctors often feel that an understanding of acceleration (G) and the effects of gravity (g) are only of importance to aerobatic or high performance aircraft pilots. This is a mistake. Because we are normally terrestrial creatures, bonding to the earth has taught us that gravity exerts a downward pull. In an aircraft however, G-forces are often upward or outward and as they are associated with changes in both acceleration and direction, what is experienced is a resultant force. It is these forces and their effects on the vestibular organs which give rise to our recognition of position in space. In the review of orientation the importance of this will be explained.

G Axes

Speed is the rate of movement of a body while velocity is a vectorial quantity made up of both speed and direction. Acceleration (G) is a change in velocity either in direction or in magnitude. It is described in three axes in

relation to the body, x, y and z. Each axis is described as positive (+) or negative (-) according to an international convention. Considerable confusion can arise if a clear distinction is not made between the applied acceleration and the resultant inertial force as these, by definition, always act in diametrically opposite directions. Thus a headward acceleration tends to displace tissues such as viscera and the eyes, footward and the resultant force is termed positive G, +Gz. (See Fig. 9).

Physiological Effects

The physiological effects of G vary with its magnitude, duration and axis of application and are modified by the area over which it is applied and the site. Tolerance to acceleration varies from day to day and is modified by body build, muscular tone and experience. It is decreased by poor health or conditioning, fatigue, hypoxia and alcohol. It can be increased by continued exposure and education. Pilots exposed to heavy G loads

soon learn to use a modified Valsalva manoeuvre with controlled breathing and muscle contraction to increase their tolerance (the M1 manoeuvre) . G-suits mechanically increase resistance to positive Gz by exerting pressure on the lower limbs and the abdomen

Figure 9

Direction of Acceleration	*Direction of Resultant Inertial Force*	*Physiological and Vernacular*	*Standard Terminology Descriptors*
Headward	Head to Foot	Positive G Eyeballs down	+Gz
Footward	Foot to Head	Negative G Eyeballs up	-Gz
Forward	Chest to Back	Transverse A-PG Supine G Eyeballs in	+Gx
Backward	Back to Chest	Transverse P-AG Prone G Eyeballs out	-Gx
To the Right	Right to Left side	Left lateral G Eyeballs left	+Gy
To the Left	Left to Right side	Right lateral G Eyeballs right	-Gy

to prevent pooling of blood. Unfortunately there is no mechanical device to counteract negative Gz.

Positive Gz

Positive Gz forces the pilot into the seat, draining the blood towards the lower part of the body. A 150 lb. pilot exposed to +4G has a weight equivalent to 600 lbs. This interferes with muscular movement, aircraft control and the ability to change position or to escape in an emergency. As G comes on and blood is drained from the head, the first symptom is visual. The normal intra-optic arterial pressure is 20/25 mm. of Hg. and under loads as low as 2-3G peripheral vision is decreased due to retinal anemia. This leads to "*grey-out*", a condition in which peripheral vision is progressively lost and central vision begins to lose its acuity. As the G load increases the retinal arterial flow is further reduced until "black-out" occurs. At this point, although vision is absent, the cerebral blood flow is often maintained and the pilot may remain conscious. At 5-6G however most pilots become unconscious unless they are protected. This is referred to as G-LOC. (G-Loss of consciousness). When the G load is reduced, consciousness will be regained although there is often a brief period of confusion before full awareness is reached. If the G load is high and the onset is of short duration, G-LOC can occur without warning. This has been determined as the cause of several accidents in high performance aircraft.

Negative Gz and Jolt

Negative Gz, acting from the foot to the head, is poorly tolerated by the body and in most cases the threshold is below -5 Gz. As might be expected the visual symptom is "*red-out*" as blood is forced towards the head and into the retinal arterioles. Excessive -Gz leads to hemorrhages into the conjunctiva and ultimately into the brain.

A special form of G is known as "jolt". Jolt is the *rate of change of acceleration*. It is descriptively used in relation to short, sharp accelerations. This type of shock can give rise to serious spinal injuries and must be minimized in the design of ejection seats.

Brief alternating positive and negative Gz forces are experienced in turbulence and may be a serious problem when flying light aircraft in hot weather or flying high speed aircraft at low levels. G-forces not only interfere with precise flying but are also a potent source of fatigue.

Transverse and Lateral G

Tolerance to transverse G (Gx) is much higher. It is for this reason that the astronauts in the early vehicles were placed in a recumbent position during lift-off. Forces as high as +60 Gx have been experienced over short intervals without injury. However, G interferes with both lung inflation and respiratory movements and forces greater than +20 Gx quickly lead to breathing difficulties. -Gx is less well tolerated. Gy is not of great enough amplitude to cause problems in consciousness and is not a problem with modern day aircraft. It does come into account however in VTOL aircraft such as the Harrier which is able to "VIFF" (Vector in forward flight) sideways to evade attack. At present, head restraint is the only problem experienced with Gy.

ORIENTATION AND DISORIENTATION

To the earth bound individual, orientation means being aware of one's body position relative to the earth. Gravity acts towards the centre of the earth and is recognized as down. The aviator however lives in a different world, a world in which proprioceptive senses may give rise to false information. At the top of a loop for example, where centrifugal force replaces gravity, down appears to be up and up appears to be down!

Disorientation, in the pilot's sense, (sometimes described as "vertigo") is to be unable to locate oneself in space and can be one of the most terrifying and lethal of experiences. It has been invoked as a contributory cause in 12% of general aviation accidents and in 15-20% of military accidents. We orient ourselves by vision, the vestibular system and by proprioceptive nerve data. The mental images of orientation that we derive from these impulses are learned from birth and relate to our terrestrial habitat. So strong are these sensations that it is possible to produce nausea by placing us in an environment where what we see is different to what we feel. This is the theoretical basis of motion sickness and will be described later.

Vision

Vision is the strongest orienting sense, and the one to which we turn when other senses fail. It is functionally divided into two parts. One, employing central foveal vision and sharp focus, is concerned with object recognition and is used together with learned conditioned reflexes in instrument flight. The other, ambient orientation, is peripheral, less acute and is directly connected to vestibular function. That the two parts of vision are independent can be observed in a driver who reads a map and follows the road at the same time. Although we can orient ourselves and function normally when the vestibular apparatus is absent or ablated, without vision orientation is much more difficult. However vision can also give rise to illusions both of location and of movement. How strong an impression it can give is amply demonstrated by experiencing an IMAX® movie where the camera appears to plummet the viewer through a ride on a roller coaster!

The Vestibular System

The vestibular system has three functions. It acts to stabilize vision via the oculo-vestibular reflexes, to orient the body in relation to movement in the environment and to give a perception of motion. These functions are performed by two 1.5 cm. structures imbedded in the petrous bones of the skull. Each vestibule (see Fig. 10) consists of three bony, semi-circular canals lined by tubules containing endolymph. Each canal lies in a separate plane of space: one is horizontal, one vertical and one lateral. The canals sense angular accelerations in the planes of yaw, pitch and roll respectively. They are connected at each end to the utricle, a dilated central area in which are the ampullae. In the ampullae delicate hair cells topped by a gelatinous cupola project into the endolymph and move with it like river bottom plants in a current.

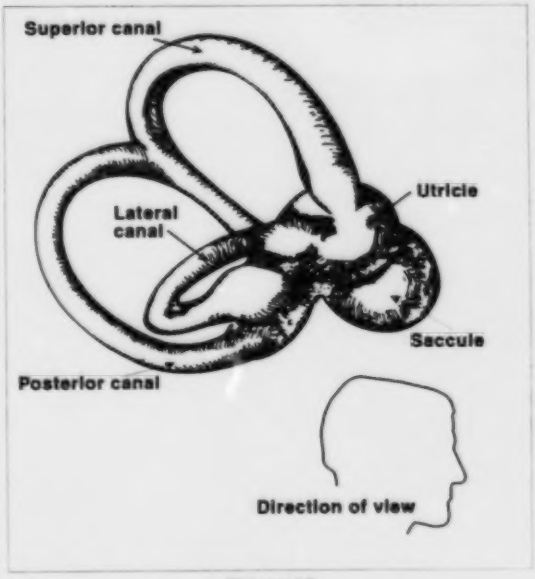

Figure 10

View of the Right Labyrinth

The utricle is connected to the saccule and in the floor of these chambers are the macula (sacculi). The macula in the utricle lies in the horizontal plane and that in the saccule lies in the vertical plane. The maculae consist of hair cells projecting into the

endolymph and covered by a gelatinous membrane containing tiny calcium carbonate crystals. They are referred to as otoliths and act as linear accelerometers.

The vestibular apparatus has connections to the visual cortex, to the innervation of the extra-ocular muscles and to the vestibular nuclei in the cerebrum. Try holding your hand up in front of your face and then moving it from side to side. The movement does not have to be fast before focused vision of the fingers is lost. Holding the hand still however and moving the head from side to side allows sharp focus to be maintained at much greater rates. Occulo-vestibular reflexes make this possible.

Proprioception

Proprioception is of only secondary importance to vision on the ground, but is much less reliable in the air. While flying, centripetal and centrifugal forces compete with gravity and proprioception may be confused. Although proprioception enables the pilot to stabilize his body in the cockpit and gives valuable clues to changing directions and attitudes in visual flying conditions, in instrument conditions "flying by the seat of the pants" can rapidly become lethal. In one experiment private pilots untrained in isntrument flying were placed in a simulator and taken from visual flying conditions into dense cloud where they were required to make a 180° turn. All crashed within 178 seconds!

Visual Illusions

These may be foveal or vectional, that is concerned with central vision or orientation vision. The former type is often associated with landing approaches and is most common where visual clues are reduced or unfamiliar. A pilot approaching an unfamiliar runway with a minor uphill slope, for example, may feel that he is too high and may fall below the normal glide slope. If the fields runs down hill, he may land long. Pilots inexperienced in the Arctic may miscalculate their height on final approach because the trees they use for unconscious reference are shorter than trees in the South. Landing in "whiteout" conditions, where the ground and horizon are obscured, or landing on a smooth, reflective lake makes judgement of height extremely difficult. Particular problems may occur at night when approaching a lighted runway in an otherwise featureless area if in the distance there is a well lit town at a higher elevation. The eye, in the absence of other clues, tends to place the two lighted areas on the same elevation which may lead to premature ground contact.

Autokinesis

There is a special problem at night with small light sources, such as stars or distant ground lights. When watched intently they will appear to move and may be mistaken for other aircraft. This movement of stationary objects is known as autokinesis and has been responsible for accidents. Where the light source is bright or large this illusion is uncommon.

Vectional Illusions

The commonest type of vectional (movement) illusion is that experienced sitting in a car at a traffic light when the adjoining car creeps forward. This causes a sensation of backward movement and often reflex braking. In the rotational plane similar illusions occur. In a darknened chamber where light from a rotating source is reflected on the walls, the movement of the light on the walls is soon replaced by a sensation of body rotation, the walls appearing fixed. Other problems are confusion between ground lights and the stars when flying over prairie areas or pilots orienting the aircraft to sloping cloud decks or to the Northern Lights rather than to the true horizon.

Vestibular Illusions

These may arise from the otoliths, the semicircular canals or from a combination of the two. They are among the most serious of the illusions and the most likely to cause lethal accidents.

At rest or in constant motion gravity is the only force acting on the otolithic membrane. We are used to interpreting gravity as a force pointing to the centre of the earth and, when our plane of movement is changed, falsely interpret sensations according to this precept. A pilot accelerating down the runway and rotating to lift-off is exposed to an acceleration which pushes him back in the seat, together with the force of gravity acting downwards. (Fig. 11). The resultant is interpreted as a single force acting downwards and backwards. Because the brain interprets the force of gravity as being vertical, the sensation is of pitch-up and the pilot may instinctively make a forward stick movement for control. This can complicate the situation because causing negative G stimulates an oculo-vestibular reflex movement of the eyes which gives rise to the sensation that the instrument panel is

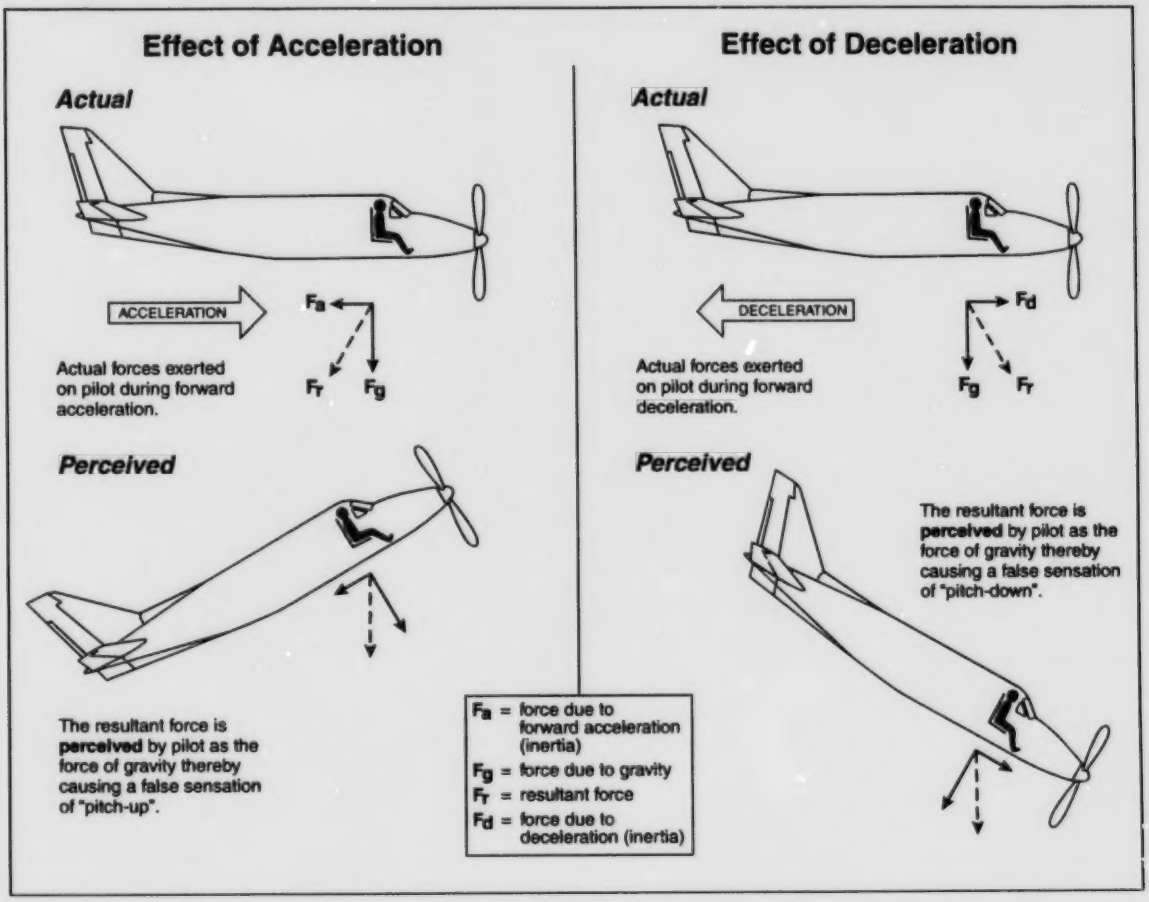
Effect of Acceleration
Actual
ACCELERATION
Fa
FT
Fg
Actual forces exerted on pilot during forward acceleration.
Perceived
The resultant force is perceived by pilot as the force of gravity thereby causing a false sensation of "pitch-up".
Effect of Deceleration
Actual
DECELERATION
Fd
Fg
FT
Actual forces exerted on pilot during forward deceleration.
Perceived
The resultant force is perceived by pilot as the force of gravity thereby causing a false sensation of "pitch-down".
Fa = force due to forward acceleration (inertia)
Fg = force due to gravity
FT = resultant force
Fd = force due to deceleration (inertia)

Figure 11

moving upwards, heightening the illusion. This is the known as the *oculogravic illusion*. With deceleration, such as that experienced on descent when the flaps are deployed, a pitch down sensation may be felt. These sensations are normal and of no great importance if the pilot is experienced or visual flight is maintained. At night however, particularly taking off from a lighted runway into a dark featureless area, and accident can occur due to inappropriate control movements performed in the transition from visual to instrument flight. Even an experienced pilot can take as long as 7 seconds to adjust.

The Leans

A common form of disorientation is a sensation of incorrect rotation (or absence of rotation) caused by the semicircular canals. The cupola in its neutral position is upright. When the head rotates, the bony canals move but there is inertia in the endolymph. The cupola is therefore deflected leading to a sensation of rotation. Our sensitivity to rotation however is not perfect and can be diminished by any form of distraction. Rotation in the vertical axis of 1-3° per second may not be perceived. If a pilot, flying straight and level, gradually drops the left wing by 15 degrees whilst otherwise occupied and suddenly becomes aware from the instruments of this attitude and corrects it at a much faster rate, only the correction will be sensed. The pilot then feels as though the aircraft has rolled 15 degrees towards the

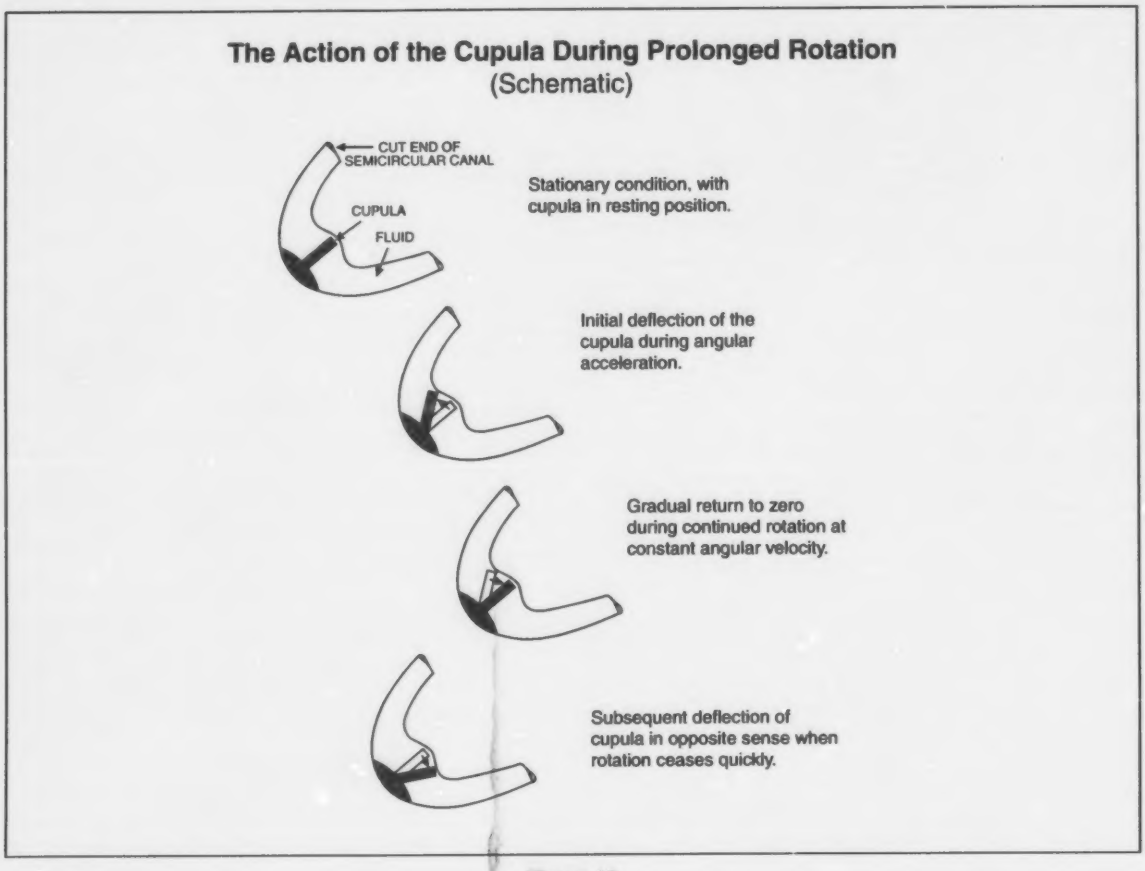
The Action of the Cupula During Prolonged Rotation
(Schematic)
CUT END OF SEMICIRCULAR CANAL
CUPULA
FLUID
Stationary condition, with cupula in resting position.
Initial deflection of the cupula during angular acceleration.
Gradual return to zero during continued rotation at constant angular velocity.
Subsequent deflection of cupula in opposite sense when rotation ceases quickly.

Figure 12

right and will lean towards the left to maintain balance. This is called "*the leans*" and is extremely common.

Prolonged Turns

A different problem arises with prolonged turns at a constant rate, such as those encountered in a holding pattern at a busy airport. On entering a turn the cupola is deflected by the inertia of the endolymph (see Fig. 12). As the turn continues the endolymph will begin to move until it is in equilibrium with the bony canal and at this point the cupola will return to its central position. (Depending on the steepness of the turn this may occur in 10-30 seconds). When the turn is terminated the bony canal will cease to rotate immediately but the endolymph, due to inertia, will continue to swirl thus moving the cupola in the opposite direction. This gives rise to the impression that a turn in the opposite direction has been entered and the tendency will be to correct this and so to re-enter the original turn.

The Graveyard Spiral

Although this is a minor distraction under most circumstances, in instrument meterological conditions it can be extremely serious and lead to a "graveyard spiral". Here the inexperienced pilot, having inadvertently entered a steep descending turn under instrument conditions, makes the correct stick movements to control the aircraft but experiencing the sensation of entering a turn in the other direction may re-enter the spiral. As the aircraft is also descending, pulling back on the stick to stop the loss of altitude, although giving rise to a comforting feeling of gravitational pull in the seat, actually steepens the spiral, ultimately driving the aircraft into the ground.

The Coreolis Phenomenon

The most extreme form of vestibular disorientation is due to the Coreolis phenomenon. This is thought to be caused when two different semi-circular canals are stimulated at the same time. As an example, a pilot taking off from an airport in instrument conditions, banks towards the left while climbing. So far there is stimulation of the otolith and of one canal. In order to reach a switch or see a gauge however the pilot turns the head quickly downwards and towards the right. Two different canals have now been stimulated and, as all are connected, a movement of endolymph takes place in the third canal. The result is a sensation of tumbling which may be extreme and worsened by visual problems due to oculo-vestibular reflexes. Even if control of the aircraft can be maintained under these very trying circumstances, the pilot may still be subject to the leans or other abnormal sensations until able to obtain a visual reference.

Types of Illusions

Distinction is sometimes made between two different type of disorientation. Type I is unrecognized and Type II recognized. Obviously a Type I illusion is more likely to lead to an accident or incident. Illusions are also divided into oculo-gyral (somato-gyral) or oculogravic (somato-gravic). An oculo-gyral illusion is defined as the apparent movement of an object in the visual field resulting from stimulation of the semi-circular canals by angular acceleration. An oculo-gravic illusion is the false perception of tilt induced by stimulation of the otolith by linear accelerations. The terms somato-gyral and somato-gravic refer to the resulting body sensations.

MOTION SICKNESS

The relationship between this condition and orientation is striking. The causes of motion sickness are both visual and mechanical, the latter arising from stimulation of the vestibular system. Animals in whom the vestibular system has been ablated or people born with non-functioning labryinths cannot be made motion sick. The cause of motion sickness has never been completely clarified but it is felt that it results from sensory conflicts, the difference between what is seen or felt and previous orientational experience. Motion sickness, for example, can occur in aircraft simulators and is more common amongst pilots experienced on the type of aircraft being simulated than it is in an inexperienced crew. It seems that the experienced pilot misses the cues of mechanical motion to which he/she is accustomed when the sensation of motion is only visually induced.

Frequency

Motion sickness increases in frequency up to puberty and then decreases. Women are more subject than men and it is more common in passengers than in aircrew. Motion sickness may be provoked by anxiety, fear or orientational insecurity. Unfortunately it can become a conditioned reflex. A trainee pilot, having been motion sick during flight, may become ill on the ground approaching an aircraft. It can be overcome by repeated exposure or adaptation and is rarely experienced by the person in charge of the aircraft (or automobile) who is aware, and braced for, changes in attitude or direction. Up to one third of military flight trainees become air sick at some point in their training and about 1 in 5 suffer severe air sickness. Despite this less than 1% of the trainees are failed because of this problem. Adaptation depends upon gradually increasing stimulation. In trainee pilots who develop severe problems, desensitization programs have been successfully employed.

Treatment

Motion sickness can be much reduced by the use of Scopolamine and nowadays transcutaneous administration of this medication is used in sea sickness. The drug however creates drowsiness and cholinergic effects and is *not suitable* for pilots. Small doses of the drug may be used in the initial phases of training when an instructor is in the aircraft but this must be discontinued before solo flight is undertaken. There is no place for prolonged drug therapy in aircrew.

Space sickness is a problem in astronauts and is suffered by 50-80% in the first few days of space flight. Adaptation however takes place rapidly and the problem is not found after three days. At present astronauts are premedicated with a combination of dexamphetamine and scopolamine prior to their take off.

NEUROLOGY

CANADIAN GUIDELINES FOR THE ASSESSMENT OF NEUROLOGICAL FITNESS IN PILOTS, FLIGHT ENGINEERS AND AIR TRAFFIC CONTROLLERS

FOREWORD

A continuing challenge for those involved in the aeromedical certification process is in making decisions which take into consideration both the rights of the individual and the safety of the public. This is not always an easy task.

One of the areas that has been most challenging is neurology and neurosurgery. Making predictions about the likelihood of subtle or sudden incapacitation is at best an imprecise science. However, modern neurological diagnostic imaging techniques and prospective studies are making outcome predictions more reliable.

These guidelines have been prepared to assist practicing physicians determine whether or not their pilot patients may meet the neurological requirements for the aviation environment. The guidelines are the result of an analysis of the proceedings of a 2 day workshop on neurological disorders and aeromedical certification held in Ottawa, June 3rd and 4th 1992.

Physicians are reminded that this document should be used as a guide only and should not be confused with the medical standards for aviation personnel published by Transport Canada, Aviation (TP195). Specific questions should be directed to the nearest regional aviation medical office, Civil Aviation Medicine Division, Health Canada. (appendix)

To all the panel members who participated in the workshop with such enthusiasm, and who gave so generously their expertise and precious time in the development of these guidelines I extend to each of you my sincere and respectful gratitude.

To Dr. Hyman Rabinovitch, neurology consultant to the Civil Aviation Medicine Review Board, and Dr. James M. Wallace, Senior Consultant, Operations Policy and Standards who shouldered the responsibility of writing and editing this document, I thank you for your dedication.

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Introduction

The Canadian Charter of Rights and Freedoms which was enacted in 1982 has a number of human rights provisions, one of which states that "no person shall be discriminated against on the basis of disability". Given this constitutional background there have been an increasing number of challenges in the Courts and Human Rights Tribunals on refusals to medically certify applicants with neurological disorders. Aeromedical "unfit" assessments must therefore be based on current scientific "state of the art" knowledge.

In the aviation environment neurological disease is a recurring concern for those involved in aeromedical certification. The mode of presentation may vary from full-blown grand mal seizures or massive stroke to the insidious onset of cognitive impairment in conditions such as multiple sclerosis and Alzheimer's disease. The prevalence and marked variability in severity of migraine has caused difficulty in objectively deciding where the line should be drawn between "fit" and "unfit" assessments. The person who has sustained a significant head injury is subject to the dual dilemma of risk of posttraumatic seizures and also of cognitive impairment.

In 1977 in the United States, the Federal Aviation Administration solicited a proposal from the American Medical Association (AMA) to produce an authoritative report on neurological disorders and aviation safety. The AMA in conjunction with the American Academy of Neurology and the American Association of Neurological Surgeons convened a series of meetings with experts in the field which resulted in the publication in 1979 of a special issue of the Archives of Neurology, entitled "Neurological and Neurosurgical Conditions Associated with Aviation Safety". This document served as one of the primary resources for Canadian aeromedical certification decisions on neurological disorders throughout the 1980's.

Advances in diagnostic imaging and the management of neurological and neurosurgical disorders over the intervening years indicated that more current references were required. In order to address these issues, Health & Welfare Canada's Civil Aviation Medicine Division held a conference in June 1992 in Ottawa, inviting experts in the field of neurology to discuss the more common neurological disorders and their relationship to aviation safety.

The conference served as a basis for the series of guidelines published below.

It should be pointed out that this document is only guidance material and that each decision will be based on the individual circumstances of the case.

Head Injury

General

There are two major concerns following head trauma resulting in loss of consciousness. One is the neuropsychological consequences of the trauma in patients who have not had any focal deficits. The other is the possibility of seizure secondary to the trauma.

The neuropsychological consequences are secondary to the effects of acceleration/deceleration forces on the skull and brain. Because of the anatomy involved, these forces cause their greatest focal damage to the orbital, frontal and anterior temporal areas of the brain. Associated with the cortical damage there is diffuse white matter damage.

The result of this is dysfunction in a number of functional executive activities of the brain. These frequently are, 1) slowing of reaction time, impaired memory and deficient ability to perform constantly at a high level over time, particularly in settings of complex activities and choices. 2) A high propensity for further mental decline with fatigue. Other problems include attention, initiation and proper sequencing of tasks, difficulty in planning and anticipating the future, and difficulty establishing automatic responses to a trigger. The affected individual may not notice or care that the task is being poorly performed. Problems are exacerbated by stress, fatigue and pain and the handling of simultaneous emergency tasks is particularly affected. Although the problems may be severe, routine IQ and mental status testing may be within normal limits. Fortunately, there is a natural tendency for deficits to improve.

Prediction of Neuropsychological Outcome

Sufficient data to accurately predict the outcome of most types of head injury is unfortunately unavailable. There are a number of ways to predict the outcome of head injury and the most commonly used to date has been the duration of post-traumatic amnesia (PTA). Most individuals who have had a PTA of less than 30 minutes are likely to be fit within three months. Older individuals and/or those who have a history of previous concussion are of greater concern. A person with PTA lasting more than 30 minutes but less than 24 hours will likely be fit from a neuropsychological point of view after a longer time, probably one year.

Those with focal neurological deficits, those who have focal abnormalities on CT scanning or a more prolonged PTA require neuropsychological assessment with particular attention to frontal lobe functioning before medical certification. Flight simulator testing may be useful. Magnetic resonance imaging (MRI) is more sensitive than CT scanning in defining areas of frontal lobe and white matter abnormality and is therefore an important diagnostic adjunct in those who have had brain injuries. These people clearly require a more prolonged period off work than those with simple concussion.

Prediction of Posttraumatic Epilepsy

The probability of epilepsy is greater in those with penetrating skull injuries. Even with full physical and neuropsychological recovery there is an increased probability of seizures for over ten years. In general, of those who develop post traumatic seizures, 50% will occur within one year and 70 - 80% within two years. Thereafter the incidence is 3 - 5% per year up to ten years. The probability of seizures has been correlated with CT scan findings as illustrated in Table 1.

Aeromedical Status

1. Those with PTA lasting 30 minutes or less, who after the event, have a normal neurological examination without sequlae, may be medically certified in three to four months if the CT scan is normal.
2. Those with PTA lasting from 30 minutes to 24 hours but with a normal MRI and EEG, may be medically certified by one year. If a seizure occurred in the first week after trauma in an adult, a longer interval before medical certification is indicated.
3. Those with PTA greater than 24 hours but who have normal neuroimaging and neuropsychological testing, may be medically certified by two years. Flight simulator testing may provide additional valuable information in these cases.
4. Those with closed head injury with extracerebral haemorrhage, but without dural tear or intracerebral involvement may return to full duties by five years. An EEG and neuroimaging should be undertaken at that time.

5. Those with closed head injuries with associated intracerebral haemorrhage or focal deficit, but whose neuropsychological testing does not show significant residua 7 years post trauma, may be considered at that time. Those who demonstrate abnormal neuropsychological residua have been more seriously injured and should be considered individually.
6. Those with penetrating skull injuries from a missile are unfit for 15 years even if neuropsychologically normal because of the continuing excess risk of posttraumatic epilepsy.

Chronic Subdural Hematoma

These can occur at any age, though they are more common in the older age group. Individuals frequently are unaware of significant head trauma.

Postevacuation if the applicant has;

1. no sequelae and
2. no seizures in the year following surgery and
3. no significant abnormality on CT scanning and sleep deprived EEG, they may be considered for medical certification.

Table 1

RISK FACTORS FOR LATE POSTTRAUMATIC EPILEPSY

	Incidence of late seizures (%)
Penetrating injury caused by missile	53
Intracerebral haematoma - laceration	39
Focal brain damage on early CT scan	32
Early seizures	25
Depressed fracture - torn dura	25
Extradural or subdural haemorrhage	20
Focal signs (hemiplegia, aphasia, ..)	20
Depressed skull fracture	15
Loss of consciousness > 24 hours	5
Linear fracture	5
Mild concussion	1

Pagni C.A. (1990)
Post-traumatic Epilepsy and Prophylaxis:
Acta Neurochirurgica, Suppl. 50, 38-47 (1990)

Stroke And Transient Ischemic Attacks

General

Stroke is the third most common cause of death in Canada. Sudden incapacitation is a significant risk in those who have had a transient ischemic attack (TIA) or stroke. The risk is compounded by an increased risk of myocardial infarction (MI).

The Oxfordshire (U.K.) TIA[1] study showed that a person who has had a transient ischemic attack has an 8.4% risk of stroke, MI or death each year thereafter. Though endarterectomy has been found to reduce by 65% the chances of stroke from a severely narrowed carotid artery, this does not affect the chance of stroke from other unoperated blood vessels or the risk of myocardial infarction. There remains a 15.8% chance of stroke or death at two years. Antiplatelet therapy is very effective and has been shown to reduce the chances of stroke by about 30%. Nevertheless the probabilities of stroke and myocardial infarction remain high. There are beneficial effects from weight reduction, lowering cholesterol, smoking cessation and avoidance of excessive alcohol use.

The individual who has had a stroke is at a greater risk than one who has had a TIA, of having another stroke. An individual who has had a stroke involving the cortex has furthermore an increased chance of developing epilepsy in the future. For these reasons the person who has had a TIA or stroke is permanently unfit.

Modifying Considerations

The majority of strokes are due to atherosclerosis which is a progressive disease and in such cases no exception can be made. There are however some exceptions with other etiologies.

Stroke from a cause which is unlikely to recur can be reconsidered, but generally a two year waiting period is required. Those who have had a significant cortical infarct, or evidence of epilepsy remain permanently unfit, irrespective of the etiology. Examples of non recurrent etiologies are listed below.

1. CNS arterial diseases unlikely to be repeated

   A. Dissection

      Dissection of the carotid or vertebral arteries is rarely an ongoing disease. It is idiopathic or secondary to trauma. In those individuals where medical certification is being considered, there should be no evidence of false aneurysm as determined by repeat cerebral angiography either by the direct or intravenous digital subtraction method.

   B. Stroke

      Stroke in pregnancy, except during subsequent pregnancies.

   C. Anovulants

      When anovulants are considered to be the causative factor, a detailed investigation must be carried out to rule out other causes. This includes a search for other neurological, hematological or cardiovascular disorders, which may be the major contributing factor.

2. Cerebral venous

   Individuals may be certified if there is no evidence of an ongoing disease process (eg. Inflammatory bowel disease; collagen vascular disease) and if there is a defined non-recurrent process (eg. pregnancy; anovulants; trauma).

3. Subarachnoid hemorrhage (SAH)

   Most pilots who have had a SAH are permanently unfit because of persistent deficits, risk of recurrence and the risk of epilepsy. The following exceptions may be considered:

   A. Aneurysmal ruptures with successful aneurysmal

      These may be considered if there is no significant residual deficit. A repeat angiogram one to two years after the initial rupture should show the clip to be in place and no evidence of other aneurysms. An EEG at two years should show no potentially epileptiform patterns

      Neuroimaging should show no evidence of a hemispheric infarction. If these results are satisfactory, certification may be considered after a 2 year waiting period for all classes of medical certification.

B. SAH where the presumed aneurysm was not found at angiography

This category includes those who have had a typical SAH with blood in the basilar cisterns but full cerebral angiography has not demonstrated an aneurysm and neuro-imaging does not reveal any other source for the bleed. If the MRI and electro-encephalogram are normal two years post event and the individual has been completely well in the interim, consideration may be given for medical certification.

4. Arterio-venous Malformations (AVM)

Most individuals who have an AVM are unfit because of the risk of bleeding or seizures. The rare individual with a small AVM which has been completely resected or obliterated and has no significant neurological residua, no seizures post event and in whom neuroimaging shows no evidence of recurrence, may be considered for certification after two years.

Asymptomatic Individuals at Risk for Stroke

Certain neurologically asymptomatic individuals may be unfit because of their high risk of future stroke. In cases where there is a 75% or greater stenosis of either carotid artery, individuals are unfit because they have been shown to have a 20% or greater chance of developing TIA or stroke in the next three years.[2] There is a similar probability of a myocardial ischemic event.

References

1. Dennis M., Bamford J., Sandercock P., Waslow C.: Prognosis of Transient Ischemic Attacks in the Oxfordshire Community Stroke Project –Stroke 1990: 21: 848-853.

2. Chambers, B.R., Norris, J.W.: Outcome of patients with asymptomatic neck bruits. N. Engl. J. Med. 1986: 315: 860-5.

Seizure Disorders

General

The tendency towards epileptic seizures is not an all or nothing phenomenon. Most people, under certain conditions, may have a seizure if sleep deprived or withdrawing from alcohol or benzodiazapines, especially if, in addition, they are taking medications which decrease the seizure threshold (eg. Tricyclic anti-depressants). Approximately 2% of the population will have a seizure during their lifetime.

An adult with a single seizure has a 30 - 40% chance of recurrence. Those with a distinct epileptiform abnormality on the EEG as opposed to non specific abnormalities, have an increased probability of having further seizures after a single seizure. It is therefore imperative that the diagnosis of a seizure be correct, and the importance of a description of the event cannot be overemphasized. Although the EEG is particularly useful it must be reviewed by an experienced reader to be considered supportive of an epileptiform tendency. Individuals with **epilepsy** are unfit.

Persons who have had the following types of seizures may be acceptable. Childhood **febrile seizures** which are brief, not associated with neurological deficits, and have ceased before the age of five may be considered for medical certification. The individual must have been off all anti-epileptic medications for at least five years and the EEG (off medication) must be normal. The seizures of Benign **Rolandic Epilepsy of Childhood** usually involve the face, tongue or hand and are often precipitated by drowsiness or sleep. The EEG shows significant abnormalities from the Rolandic area of the brain. Individuals with this condition may be considered for medical certification if they have been seizure free and off medication for ten years. They must have a normal neurological examination and EEG. A sleep deprived EEG should also be normal.

The Single Epileptic Seizure

An individual with a single epileptic seizure is initially unfit. The case can be reconsidered after five years if the neurological examination is normal and repeated EEGs, including sleep deprivation and additional nasopharyngeal or minisphenoidal electrodes, do not reveal any significant abnormalities. Neuroimaging, preferably MRI, must first have revealed a normal brain structure. A restricted (as or with co-pilot) medical certificate can then be granted. Such a restriction may be removed after an additional two years. Those individuals who have a second seizure should be considered to have epilepsy.

Five years after the event, all of the above investigations must be repeated and found to be normal. Applicants for Category 1 medical certification should be restricted to: "as or with co-pilot" for an additional two years. Those individuals who have a second seizure should be considered to have epilepsy.

When a single seizure was related to alcohol withdrawal, individuals may be considered earlier if they have a normal EEG and neuroimaging and psychosocial and biochemical evidence is presented that their alcohol abuse/dependence is in a continuing "recovery" phase.

Those who have had a seizure while on tricyclic anti-depressant drugs or other seizure enhancing medications must be considered more prone to seizures than the average population. They must be considered unfit for five years.

Transient Global Amnesia (TGA)

This condition is characterized by a transient loss of memory for remote events associated with an inability to form new memories. It is an unusual condition that usually lasts for hours. TGA is not a seizure disorder and may be due to transient ischemia in the inferomedial parts of the temporal lobes. It is commoner in middle aged or older people, and many individuals are hypertensive: frequently they have been undertaking physically demanding tasks (eg. shoveling snow) or under significant mental stress at the time of the attack.

Throughout the episode, the sufferer is socially appropriate, oriented to person but tends to repeat the same question over and over again, this question usually reflecting their disorientation. (eg. "What am I doing here?") A number of series have shown a 10 - 20% recurrence, most of which occur within the first five years.

If there is a normal neurological examination and EEG at the time of the event and again two years after the event, medical certification may be considered.

Current neurological opinion suggests that TGA may be a migraine like phenomenon.

Narcolepsy

Narcolepsy presents with periods of excessive daytime sleepiness not prevented by adequate night-time sleep and often enhanced by boredom. Excessive sleepiness may be associated with sleep related hallucinations or paralysis and, most importantly, it may be associated with **cataplexy** which is an abrupt paralysis of variable degree precipitated by surprise or by laughter. Prophylactic medications are imperfect and may alter performance. They include dextroamphetamine and methylphenidate.

Narcolepsy is a lifetime illness and the sufferer is permanently unfit.

Headaches

TENSION AND MIGRAINE HEADACHES

General

Fifty-nine percent of the adult population in Canada report some form of headache. Thirty percent suffer from tension-type headaches, and 17% suffer from some form of migraine. Tension type headaches are not usually disabling but up to three quarters of migraine headaches are sufficiently severe to limit regular activities. Most migraineurs have attacks that last 12 to 24 hours.

Migraine can be divided into two categories, migraine with aura (classical migraine) and migraine without aura (common migraine). The aura may be preceded by a prodrome of mood changes which may interfere with routine activities. The aura itself usually lasts about 20 minutes and immediately precedes the onset of the headache. The cause of the aura has been debated but may be secondary to metabolic and/or electrical changes which may possibly be accompanied by ischemic change in the cerebral cortex. The head pain itself is thought to be related to a sterile inflammatory response around blood vessels in the face and scalp and the intra-cranial vessels of the coverings of the brain. This inflammatory response is mediated through vasoactive peptides which cause dilatation, edema and inflammation around the vessels which are innervated by a branch of the trigeminal nerve (trigeminal-vascular complex).

Migraine tends to occur at times of let-down from stress, after fasting, and after missing sleep. Flashing lights and bright reflected light may also trigger acute attacks.

Aeromedical Status

Migraine without aura – Most applicants will be considered fit.

Migraine with Aura

Group 1.

Applicants with auras which:

a) would not interfere with flight safety and,
b) have been consistently the same aura over several years, can generally be considered for medical certification.

Group 2.

Applicants with auras that:

a) are of slow onset; and
b) occur infrequently ie. once every several months; and,
c) are not associated with cognitive impairment, but may cause minor sensory difficulty that does not impair performance; and
d) have been consistently the same over several years.

3. Migraineurs who have significant auras which can interfere with flight safety and who do not fit into the group 2, (ie, too fast onset, too frequent, cognitive impairment, unclear history,) should generally be considered unfit for all categories. They may be considered for restricted medical certification if after 3 years they fit in group 2.

Cluster Headaches

Cluster headaches occur only in 0.1% of the population and are generally episodic and 80% of the cases occur in men. The headaches usually last about one hour and 50% of the cases begin during sleep. They recur in bouts lasting six weeks or more, during which time acute attacks occur one to four times per 24 hours. Once the bout is ended, however, the sufferers are usually entirely headache free for months or years. The individual attacks are extremely intense, localized around one eye and associated with nasal congestion and lacrimation which may impair vision. They are virtually always incapacitating. The applicants should be considered unfit during a bout of cluster headache but during the interval bouts, they may be considered fit. Between bouts, the applicants do not need to take any medication, but in chronic cluster headache where the bout extends beyond six weeks, medication which might impair functioning may be required.

Trigeminal Neuralgia

Trigeminal neuralgia causes piercing, electric shock-like facial pains which have a high frequency of recurrence. Many episodes may occur in a single day.

In older age groups these are often secondary to a loop of blood vessels pressing against the trigeminal nerve: in the young they may be secondary to multiple sclerosis. Individuals suffering from trigeminal neuralgia are unfit but if they go into remission may be considered for medical certification.

Multiple Sclerosis

General

Multiple Sclerosis (MS) has a prevalence of about one in a thousand in Canada. The peak incidence is in the early 30's with more females than males being affected. It is the third most common cause of severe neurological impairment in the 15-60 year age range. The course is variable. Some will have a relapsing, remitting course and 20 - 30% will have a benign course. Fatigue is one of the most disabling problems in patients with multiple sclerosis. In 60% of the patients the symptoms are exacerbated by an elevated ambient temperature.

Flight Safety Concerns

1. Functional Disabilities

   Though many of these will be readily apparent from a practical flight test, (eg. weakness, lack of coordination etc.) they also include problems with excessive glare in bright light and increased levels of fatigue.

2. Neuropsychological Deficits

   40% of the patients with MS have been found to have neuropsychological problems. This is significantly but weakly correlated with the degree of functional disability.

3. Paroxysmal Events

   Epilepsy occurs in 5% of patients with MS. Trigeminal Neuralgia is commonly a symptom of MS when it occurs in the young. Paroxysmal dysfunction of motor or sensory systems may occur with this disease.

Recommendations

1. **Functional Disabilities**

   Individuals with functional disabilities that interfere with the mechanics of flying or those who have a progressive course of MS will be considered unfit. This is also true of those who suffer significant fatigue or heat sensitivity. Individuals who have a remitting/relapsing course may be considered fit when they have been in remission for three months provided the remission is complete or with minimal residua (eg. Expanded Disability Score of less than 2 on a scale of 0 - 10). Such individuals will require neurological follow-up every six months.

2. **Neuropsychological Sequelae**

   Because of the concern for subtle neuropsychological deficits, applicants should probably be followed by a neurologist with expertise in M.S. Neuropsychological testing should be considered periodically especially in those who have significant fluctuation in symptoms. Flight simulator testing may be useful in assessing cognitive function. The role of MRI to delineate those who may have neuropsychological deficits has not been defined at this time. Those with marked involvement of the white matter with MS plaques, particularly if the involvement is bifrontal, should have neuropsychological testing and, if indicated, a practical flight test.

3. **Paroxysmal Events**

   A. Epileptic Seizures

   These individuals are permanently unfit.

   B. Trigeminal Neuralgia

   Applicants are unfit during periods when they are symptomatic. It is unusual for these to resolve and most continue to be unfit.

   C. Other Paroxysms

   Usually these are of limited duration. If they resolve and are absent for four months off medication the individual can be reconsidered for medical certification.

Tumors

General

Tumors arising from the brain parenchyma such as gliomas or ependymomas, even when removed and whether or not they are treated with a radiotherapy, leave behind scarring. This increases the probability of seizures and applicants with such a history are therefore permanently unfit.

Meningiomas

Applicants who have had meningiomas of the cerebral convexities may be considered fit two years post resection under certain specific circumstances. Current literature suggests that there is no limit as to when a meningioma can recur. The tumor must have been fully removed as defined by repeated neuroimaging. There should be no neurological sequelae and no history of seizures in association with the tumor. If a medical certification is granted a repeat EEG and CT scan must be done at yearly intervals.

Infratentorial Meningiomas, Acoustic Neuromas, Pituitary Tumors and other Benign Extra-axial Tumors

Applicants who have had complete resection of an infratentorial meningioma, acoustic neuroma or other benign extra axial tumors, or applicants who have had a transphenoidal complete resection of a pituitary tumor and have no neurological or endocrinological sequelae and no history of seizures may be relicenced after 6 months to one year. They will require yearly neurological and endocrinological follow-up.

Those who have had an elevation of the frontal lobes in order to approach the pituitary tumor are generally unfit. This is because the tumor is probably larger and more likely to disturb structures around it and the frontal lobe has been disturbed by the traction involved in the surgery. These factors increase the chance of the applicant developing seizures.

Miscellaneous Illnesses

Hydrocephalus

Individuals who have required a shunt to control hydrocephalus may have shunt failure and/or require a new shunt. Those shunted for acquired hydrocephalus are generally unfit because of the possibility of unexpected shunt failure. Individual consideration however may be given where accredited medical opinion is that the risk of shunt failure or seizure is low.

Applicants shunted in infancy and seizure free throughout adult life without neuropsychological sequelae may be considered for Category 3 medical certificate.

Syringomyelia

This is a rare condition in which there is a cystic lesion of the spinal cord or brainstem. These lesions usually develop because of congenital anomalies, less frequently secondary to trauma or tumor. They tend to progress.

If the syrinx is below the cervical cord the applicant should be judged as any other paraparetic according to functional abilities. A practical flight test will be required and, after medical certification, neurological follow-up is required every six months. A practical flight test should be repeated annually.

In applicants where the syrinx involves the cervical cord or brainstem, the neurological deficit may be or become too significant for medical certification. Such applicants are permanently unfit.

Myasthenia Gravis (MG)

Neuromuscular dysfunction in MG is related to antibodies generated against the acetylcholine receptor at the neuromuscular junction. This results in progressive weakness and fatigability which fluctuates with the degree of effort sustained. Some individuals may achieve a remission by thymectomy or immunosuppression. Those who are in remission and stable, with little or no medication two years after the thymectomy, may be recertified.

Infections

1. **Viral Meningitis**

   An applicant who is neurologically normal at two months after infection will be considered fit, all categories.

2. **Bacterial Meningitis**

   If the individual is found to be neurologically normal on examination, electroencephalography and CT scanning and if they have had no focal or neurological deficits or seizures during the bacterial meningitis, they may be considered fit after one year.

   If there were complications such as focal neurological deficits, persistent cognitive deficits or seizures, the applicant must be fully neurologically intact for five years while off all medications before being recertified. A repeat CT scan, EEG and a neurological assessment should be performed at five years prior to recertification. If there were cognitive deficits post resolution, neuropsychological testing should be carried out.

3. **Viral Encephalitis**

   The most common, sporadic, viral encephalitis in North America is Herpes Simplex encephalitis. Neuropsychological sequelae are virtually always present, even in those who have survived seemingly neurologically intact.

   Generally applicants who have suffered this disease will be permanently unfit. In cases however where there is complete neurological recovery and neuropsychological testing shows no significant deficit, individuals who have not had a seizure for five years off all medication can be considered for medical certification. If the disease manifested minimal or no cognitive dysfunction then a shorter unfit period prior to medical certification may be considered.

4. **Brain Abscesses**

   Applicants who have had a brain abscess are at an increased risk for epilepsy from the scarring that forms around the abscess. They are therefore permanently unfit.

5. **Guillain-Barré Syndrome**

   Applicants who have made a satisfactory neurological recovery may be certified following a successful practical flight test.

Degenerative Disease Of the Brain

1. Parkinson's Disease

Most applicants with Parkinsonism suffer physical and/or cognitive deficits which render them unfit. Individuals who have minimal Parkinson's disease, such that they do not require L-dopa or an L-dopa agonist, may be certified. All patients licensed with Parkinson's disease must have a satisfactory neurological assessment at each renewal and more frequently if clinically indicated.

2. Dementia

Applicants with dementia are permanently unfit. In the small number of cases where the cause of the dementia is known and the condition has been resolved, applicants may be considered for recertification.

CARDIOVASCULAR

CANADIAN GUIDELINES FOR THE ASSESSMENT OF CARDIOVASCULAR FITNESS IN PILOTS, FLIGHT ENGINEERS AND AIR TRAFFIC CONTROLLERS 1995

Foreword

The presence or development of cardiovascular disease in licensed aviation personnel, with the risk of potential clinical manifestations, continues to be a major concern amongst aviation medical practitioners in industrialized nations.

As the modern methods of medical and surgical treatment of cardiovascular disease continue to improve, many pilots and air traffic controllers have been able to return, after successful treatment, to licensed duties without jeopardizing aviation safety.

This second edition of the Canadian cardiovascular guidelines to assist in the medical assessment of cardiovascular fitness of licensed aviation personnel reflects some changes as a result of discussions and recommendations during the aviation cardiology workshop held in Ottawa, on January 24 & 25 1994, arranged by Civil Aviation Medicine Branch, Transport Canada.

The ideal objective would be to prevent or at least delay as much as possible the onset of cardiovascular disease in pilots and air traffic controllers throughout their careers. With this objective in mind, the section on risk factors has been expanded to encourage medical practitioners to advise their aviation clients accordingly.

Physicians are reminded that these guidelines are to be used as a guide only, and they should not be confused with the medical regulations set out in the Personnel Licensing Handbook, Volume 3, published by Transport Canada.

Civil Aviation Medicine, Transport Canada, is again grateful for the enthusiastic support and participation of all the expert panel members, the observers, and other individuals who provided advice and criticism. It should be pointed out that individuals listed as "observers" participated actively and contributed significantly to the success of the 2 day conference.

Finally, a special work of thanks to Drs. J. Wallace and P. King for their effects in planning and co-chairing the workshop, and to Dr. A.T. Wielgosz, for his continued support, expertise, and taking on the task of writing the text.

Comments are welcomed, and any specific questions should be directed to your Regional Aviation Medical Officer, Transport Canada or Civil Aviation Medicine, Transport Canada, Ottawa.

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Introduction

Since the last guidelines for the assessment of cardiovascular fitness in Canadian aviation license holders were published in 1988 a number of innovations, particularly in interventional cardiology as well as our own experience in the application of these guidelines, have created the need for an update. Aviation Medical Standards as laid down in Annex 1 to the Convention on International Civil Aviation by the International Civil Aviation Organization (ICAO) to which Canada is a contracting state, identify broad medical conditions that on the basis of expected risk of incapacitation disqualify a pilot from flying an aircraft. Such conditions, (e.g., acute myocardial infarction) are reportable to Transport Canada and result in immediate revocation of medical certification. In countries where the standards are applied strictly, affected pilots may never return to flying. Such a strict policy may be unfair to those license holders in whom the risk of sudden incapacitation becomes acceptably low as a result of risk factor modification or rehabilitation including some therapeutic interventions.

Our ability to predict risk in any individual licence holder is improving as experience with groups of similar individuals increases. Progress with the assurance of a safe flying environment (e.g. through widespread incapacitation training), has also allowed more tolerance of certain medical conditions.

The risk of fatality in flight occurring is dependent on a number of factors including the amount of time spent flying, the risk of an incapacitation occurring at a critical phase of flight and the risk that such incapacitation will inevitably result in catastrophic accident. All of these factors must be taken into consideration in addition to the known medical risk of a given medical condition precipitating incapacitation. Experience with cardiac disease in the general population and experience with simulators allow the estimation of risk in a fashion similar to that used by structural engineers. It can be rationalized that an annual risk of incapacitation up to 2% due to a medical condition can be tolerated in the flying environment as that would translate into an acceptably low risk of a resulting fatality. Where there is insufficient precision in risk estimate for the medical condition of a given applicant, then recommendations for medical fitness should err on the side of caution.

As with the previous guidelines, a 2-day workshop to review and update existing guidelines on cardiovascular fitness was organized in Ottawa January 24 and 25, 1994 with the participation of Regional Aviation Medical Officers, cardiovascular consultants familiar with the aviation environment and staff from the Civil Aviation Medicine Branch, Transport Canada. At that time, CAM Division was part of Health Canada.

Chapter 1: Ischemic Heart Disease

ANGINA PECTORIS

Chest pain, regardless whether typical or atypical for ischemic heart disease, precludes medical certification from flying insofar as it indicates an elevated probability of significant coronary artery disease and an increased risk of an incapacitating cardiac event.

An applicant may be considered fit if diagnostic testing indicates a low probability of significant coronary artery disease or that the chest pain is not due to myocardial ischemia. If coronary arteriography reveals normal coronary arteries, coronary vasospasm should be excluded. The presence of continuing symptoms of chest pain is not disqualifying per se; however, such symptoms must not be incapacitating in any way.

MYOCARDIAL INFARCTION

Acute myocardial infarction is initially incompatible with medical certification. However, disqualification is not necessarily permanent, and medical certification may be considered 6 months (A decision at 6 months must be based on requisite assessments completed no sooner than 5 months after discharge from hospital.) after the event provided the following criteria are met:

- The result of an exercise test to at least 85% of the predicted maximum heart rate, or a minimum of 8 METS (end of stage 3) with the Bruce protocol or equivalent is normal in all respects. Cardiac medications must be stopped for an appropriate time (preferably five half-lives) before such a test.
- The left ventricular ejection fraction as a measure of left ventricular function using echocardiography or gated radionuclide scintigraphy, is better than 50% at rest and does not show a decrease of more than 5% with satisfactory exertion (i.e. 85% predicted maximum heart rate or >8 METS).
- With a satisfactory ejection fraction as described above, Holter-monitoring is not required. For an ejection fraction between 40% and 50%, a restricted license may be considered after review of a 24 hour Holter-monitor. This should reveal no more than 3 ventricular ectopic beats per hour in the absence of antiarrhythmic medication, with no more than 3 consecutive beats and a cycle length that is not less that 500 msec.
- The above assessments including the review of symptom history must be made without the effect of anti-ischemic medications that could possibly mask adverse findings.
- Major modifiable risk factors for recurrence of infarction are controlled and the applicant is a non-smoker.

The requisite assessments should be completed no sooner than 3 months after discharge from hospital.

Follow-up assessment every 12 months should include a thorough history and physical examination and a review of modifiable risk factors. A treadmill exercise test should be done at 3 and 5 years and subsequently at yearly intervals.

These criteria apply regardless of whether the applicant was treated for acute thrombosis (e.g., with a thrombolytic drug, angioplasty or bypass surgery) or the infarction occurred in the absence of significant coronary artery disease as demonstrated by arteriography.

REVASCULARIZATION

An applicant who has been treated for symptomatic or asymptomatic coronary artery disease by revascularization including bypass surgery, angioplasty, directional atherectomy etc., can be considered for medical certification after an interval of 6 months, provided the following criteria are met:

- The result of an exercise test to at least 85% of the predicted maximum heart rate or a minimum of 8 METS (end of stage 3) with the Bruce protocol or equivalent is normal in all respects. Cardiac medications must be stopped for an appropriate time (preferably five half-lives) before the test.
- Patency of the revascularized artery is maintained with no evidence of reversible ischemia on rest and exercise perfusion imaging.
- Major modifiable risk factors are controlled and the applicant is a non-smoker.

A follow-up assessment a year after the revascularize-

tion and then annually should include a thorough history, physical examination, rest and exercise electrocardiography and a review of modifiable risk factors. If there is no clinical deterioration after 2 years, the treadmill exercise test can be done every 2 years until the applicant is 50 years of age and subsequently at yearly intervals.

RISK FACTORS FOR ISCHEMIC HEART DISEASE

The following are major primary and secondary risk factors for ischemic heart disease. While many of them may have impressively large relative risks, their absolute risk, particularly for sudden incapacitation, is low. Concern about these risk factors is greater in applicants with known ischemic heart disease where the absolute risk is greater. The presence of major modifiable risk factors should be a concern in any applicant and preventive care is strongly advised.

Smoking

Prohibition of smoking on aircraft in the cockpit is strongly supported for flights of all duration. An applicant with known ischemic heart disease who continues to smoke should be made "unfit".

Increased serum cholesterol levels

All applicants are encouraged to be aware of their serum cholesterol level and to maintain a normal level. Levels above the 90th percentile (Table 1), as determined from two consecutive assessments 1 month apart, warrant aggressive intervention. All applicants with elevated cholesterol levels, particularly with a low HDL cholesterol level, should be encouraged to achieve a normal level i.e. <5.2 mmol/L.

Table 1

Serum cholesterol levels (90th percentile), by age, that warrant aggressive intervention

Age (year)	*Serum cholesterol level; mmol/L (mg/dl)*
20-29	5.7 (220)
30-39	6.2 (240)
>40	6.7 (260)

High blood pressure

Blood pressure levels have limited predictive value in isolation from end-organ disease and other risk factors. In licence holders with blood pressure levels above 140 mmHg systolic or 90 mmHg diastolic confirmed by at least 3 sets of 3 readings taken with intervals of 2 weeks or more, it is appropriate to evaluate the risk profile, search for end-organ disease (retinal hemorrhage, left ventricular hypertrophy, creatinine > 150 mmol/L, microalbuminuria) and initiate nonpharmacologic therapy.

If pressures remain above 160 mmHg systolic or 100 mmHg diastolic, drug treatment should be initiated.

If blood pressures are above 130 mmHg mean arterial pressure (D+(S - D)/3) equivalent to blood pressures of 170/110 or 190/100 mmHg, pilots should be considered unfit, investigated for underlying causes of hypertension to permit specific treatment and treated accordingly with the recommended drugs. They may be medically certified when treatment has been successful (blood pressure < 160 mmHg systolic and < 100 mmHg diastolic).

Therapeutic considerations

In licence holders, the major concerns with treatment are to minimize postural hypotension, the risks of arrhythmias and adverse CNS effects.

Drugs that are not permitted include:

1. Sympatholytics, e.g. guanethidine, _alpha-blockers.
2. High dose kaliuretic diuretics (> 25 mg hydrochlorothiazide or equivalent).
3. Clonidine and methyldopa (because of risk of rebound hypertension if these medications are inadvertently not taken).

Preferred drugs include:

1. **ß-blockers:** hydrophilic drugs are preferred (e.g. atenolol, nadolol, timolol).
2. **Calcium channel antagonists:** long-acting dihydropyridines are preferred (e.g. amlodipine, felodipine, nifedipine XL).
3. **ACE-inhibitors:** long-acting ACE-inhibitors are preferred such as cilazapril, fosinopril, lisinopril, quinapril, etc.
4. **ATII receptor Blockers:** candesartan, irbesartan, losartan, and others are similar to ACE inhibitors in their hemodynamic action. They can be used

singly or in combination. As with ACE inhibitors, ATII receptor blockers are acceptable in pilots who have been on one of these medications for a month or more without any adverse effects.

If diuretics are required for control, low doses of hydrochlorothiazide (< 25 mg/day) or potassium/ magnesium sparing diuretics such as amiloride and spironolactone should be used. The former may be comined with ACE inhibitors. Sodium restriction also helps spare potassium.

Applicants who are stable with no adverse effects while on other drugs may be considered. In cases of resistant hypertension, identification of the underlying cause will facilitate control and avoid adverse effects. Where necessary, small doses of medications in combination may lead to fewer adverse effects than larger doses of single agents.

Multiple risk factors

Coronary atherosclerosis is a multifactorial disease, the risk of early onset increasing with the number of risk factors present. Therefore in applicants the assessment of risk must weight appropriately the contribution of the various factors present. The cumulative risk conferred by the presence of more than one risk factor, even at levels only moderately above normal, can exceed that conferred by the presence of one major risk factor alone. The presence of only moderately elevated levels of risk when any risk factor is assessed alone should not lead to a false sense of security on the part of the physician or the applicant.

The **absolute risk** of developing coronary artery disease or cerebrovascular disease can be determined from Figures 1 and 2 by:

1. finding the number on the age/sex strips that corresponds to a particular patient;
2. drawing a line vertically that intersects one of the risk lines (either 5 year or 10 year risk). A line drawn from this point horizontally to either y axis identifies the absolute risk of an event in a patient without taking into account other potential risk factors.
3. Identify the risk factors and move up or down the scale the number of boxes recommended by the tables in the left upper corner of the graphs (e.g. a total cholesterol of 6.4 moves the score 3 boxes to the right. A cholesterol of 4.0 moves the score 2 boxes to the left).

The algorithm in figure 3 is proposed for the work-up of applicants in order to determine appropriate additional investigations and to initiate appropriate treatment or preventive measures. See Appendix for a specific example demonstrating the use of these data.

If on initial assessment an individual is overweight (BMI > 28 kg/m2) (BMI (Body Mass Index) = Weight (kg)/[Height (m) x Height (m)].) or a smoker (any amount) the physician should inquire about family history. If the family history is negative appropriate advice should be given about weight reduction and smoking cessation.

If the family history is positive (first degree male relative < 55 years old or female < 65 year old with ischemic heart disease) a lipid assessment should be carried out.

If the five year risk score in figure 1 exceeds 10%, then a cardiovascular assessment including an exercise treadmill test should be carried out. If abnormalities are found, resulting in an average annual mortality risk > 1% (Fig. 4) assuming an additional 1% risk of an incapacitating nonfatal event, then a licence holder is considered unfit. Even if the response to exercise testing is normal in all respects appropriate therapy to modify risk factors should be initiated.

If on initial assessment an individual licence holder's blood pressure is elevated, (e.g. > 140 mmHg systolic or > 90 mmHg diastolic), an echocardiogram should be done to screen for the presence of left ventricular hypertrophy. If this is present, a lipid profile should be determined and the rest of the algorithm followed as outlined above.

These recommendations provide a stepped approach to screening for the presence of significant ischemic heart disease based on the risk factor profile. It also provides the opportunity to identify modifiable risk factors that need attention.

COMMENTS ON SCREENING

Screening of the aircrew and air traffic controller population to identify cardiovascular disease before sudden incapacitation is a problematic and controversial undertaking. Almost every case of sudden incapacitation attributable to a cardiovascular cause brings impassioned public appeals for increased screening. It is beyond the scope of these guidelines to present the results of analyses that indicate the costs and problems of widespread routine screening. Nevertheless, a rational policy toward

screening can be adopted to provide optimal, though never total, prevention of cardiac incapacitation.

The current routine medical examination is intended to ensure that only healthy aircrew are allowed to fly. However, the onus is on the applicant to report any symptoms and on the physician to conduct a scrupulous examination.

A resting electrocardiogram may show no abnormalities even in the presence of severe coronary artery disease; in fact, this may be true in up to 50% of people with advanced coronary artery disease. Since the prevalence of ischemic heart disease increased with age, the utility of routine electrocardiography improves after age 50 and with the presence of major risk factors for ischemic heart disease. The current recommendations for routine electrocardiographic testing are considered adequate.

Compared with a resting electrocardiogram, exercise electrocardiography increases the likelihood of detection of coronary artery disease. Against the widespread introduction of routine exercise testing are concerns about inaccuracies in the interpretation of test results as well as economic and psychosocial consequences. The predictive value of a test result (i.e.. whether a test result is truly positive or truly negative) is influenced by the clinical characteristics of the person undergoing such testing. Routine screening of all applicants by a treadmill exercise test will yield false-positive results more often than true-positive results. On the other hand, the number of true-positive results, is increased significantly if such testing is applied only to people who are more likely to have coronary artery disease, such as those with symptoms of angina, those for whom major risk factors are present and those in higher age groups. Such a targeted approach will not impose a major burden and will encourage modification of risk factors.

An Example

57 year old male applicant who smokes, has a systolic blood pressure of 160 mmHg, a total cholesterol of 6.7 mmol/L, an HDL cholesterol of 1.40 mmol/L and has no history of diabetes and no left ventricular hypertrophy.

Risk of coronary heart disease (Figure 1)

1. vertical line up from 57 male to the five year risk line gives an absolute risk of 3%.
2. smoker (4 points) – go to the right (up) 4 squares (now at risk of 6%).

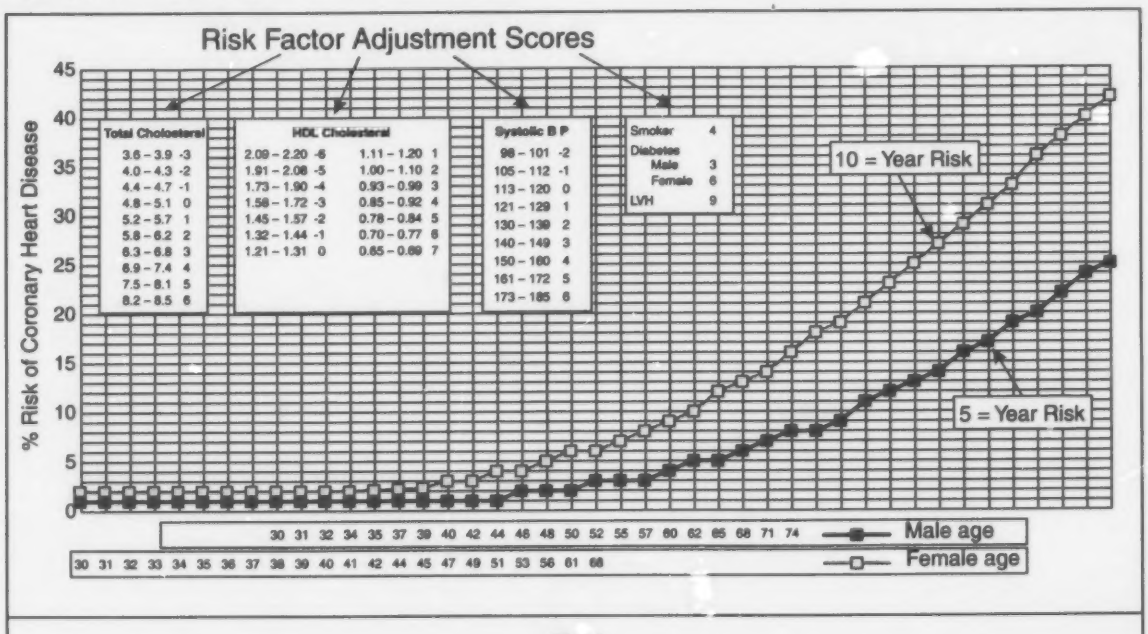

Fig. 1

Coronary artery diseases risk in a patient with no history of cardiovascular disease.

3. systolic blood pressure of 160 mmHg (4 points) – go to the right (up) 4 squares (now at a risk of 9%).
4. total cholesterol of 6.7 mmol/L (3 points) – go to the right (up) 3 squares – (now at a risk of 13%).
5. HDL cholesterol 1.40 mmol/L (-1 point) – go to the left (down) 1 square – (now at a risk of 12%).

Estimate of absolute risk of developing coronary heart disease in the next 5 years is 12%.

Estimate of absolute risk of developing coronary heart disease in the next 10 years is 23% (from the 10 year risk line).

Risk of cerebrovascular disease (Figure 2)

1. vertical line up from 57 male (use 58) to the 10 year risk in men line gives an absolute risk of 3%.
2. smoker (3 points) – go to the right (up) 3 squares (now at a risk of 4%).
3. systolic blood pressure of 160 mmHg (6 points) – go to the right (up) 6 squares (now at a risk of 10%).

Estimate of absolute risk of developing cerebrovascular disease in the next 10 years is 10% (from the 10 year risk in men line).

The following limitations apply to these data:

1. the information comes from the Framingham database and is not necessarily a true representation of the total population. These estimates, and other similar estimates have been used in an attempt to determine the number of events that would occur in a placebo group for a given period of time for some intervention trials and invariably the placebo group has fewer events (approximately 50%) than expected.
2. weight is not taken into account.
3. family history is not taken into account.
4. The information is not applicable to applicants with established coronary heart or cerebrovascular disease.

The following assumption applies:

1. the levels of two of the risk factors, blood pressure and cholesterol, are determined while not on drug therapy. Most evidence would suggest that if we reverse or change a risk factor with drug therapy we do not change the overall risk back to "normal". In other words a patient whose blood pressure is 140/90 mmHg on drug therapy is still at a greater risk than a patient

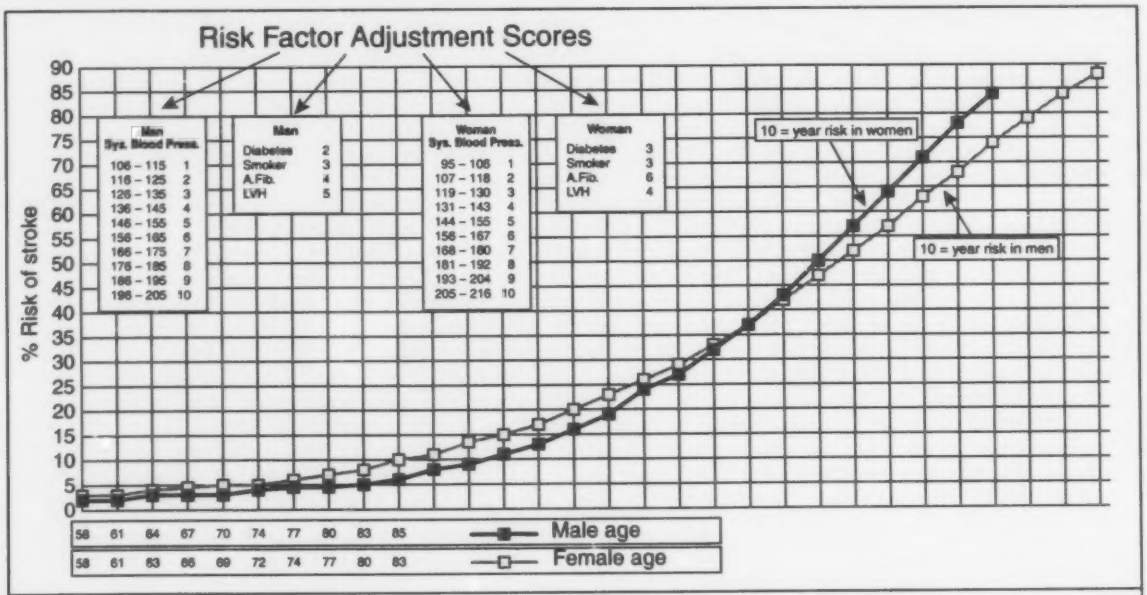

Fig. 2

Cerebrovascular disease risk in a patient with no history of cardiovascular disease.
with permission from Dr. J. P. McCormack and Dr. R. Rangno, St. Paul's Hospital, Vancouver, B.C.

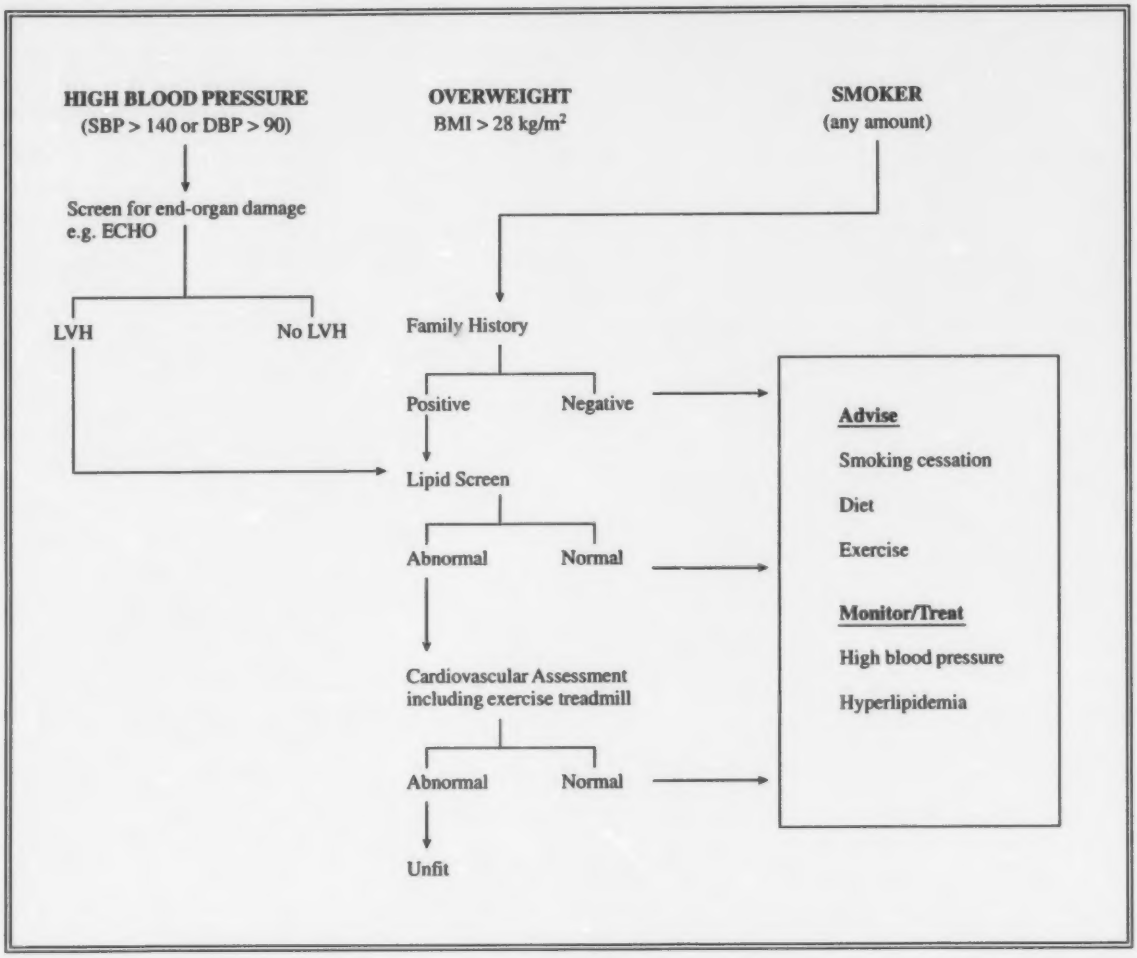

Fig. 3
Evaluation of Risk Factors

whose baseline blood pressure is 140/90 mmHg.

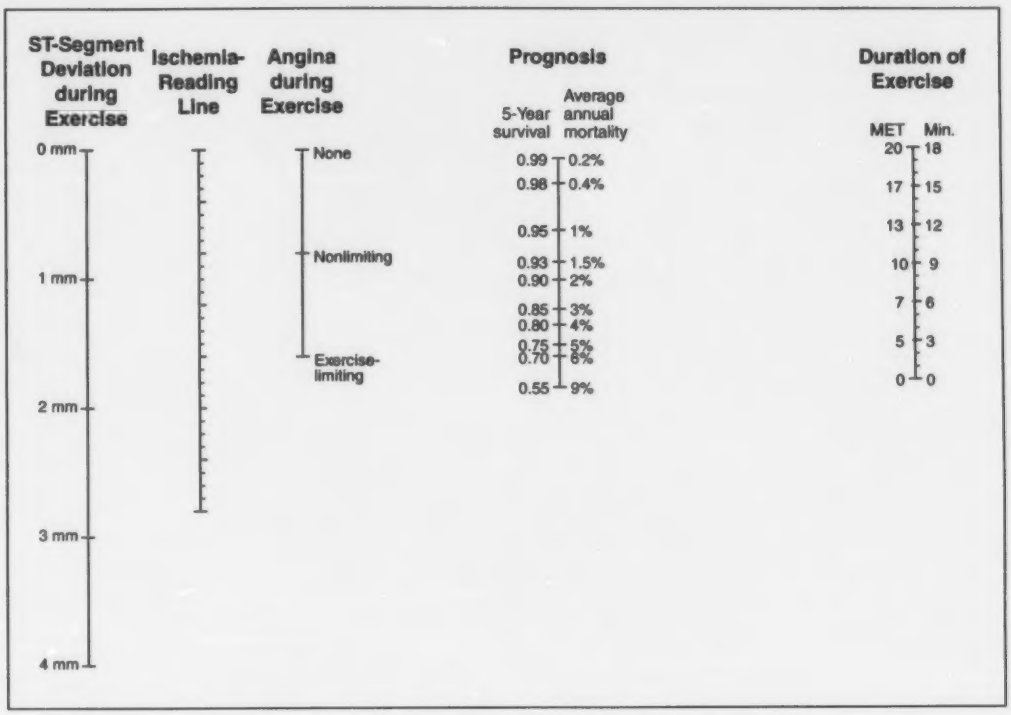

Fig. 4

Nomogram to evaluate prognosis using the treadmill score

Determination of prognosis proceeds in five steps. First, the observed amount of exercise induced S-T segment deviation (the largest elevation or depression after resting changes have been subtracted) is marked on the line for S-T segment deviation during exercise. Second, the observed degree of angina during exercise is marked on the line for angina. Third, the marks for S-T segment deviation and degree of angina are connected with a straight edge. The point where this line intersects the ischemia-reading line is noted. Fourth, the total number of minutes of exercise in treadmill testing according to the Bruce protocol (or the equivalent in multiples of resting oxygen consumption [METS] from an alternative protocol) is marked on the exercise-duration line. Fifth, the mark for ischemia is connected with that for exercise duration. The point at which this line intersects the line for prognosis indicates the five-year survival rate and average annual mortality for individuals with these characteristics. Reprinted by permission of the New England Journal of Medicine (325. P.850, 1991).

Chapter 2: Non-ischemic Heart Disease

VALVULAR HEART DISEASE

The significance of valvular heart disease depends primarily on the hemodynamic consequences, functional status and, in some cases, the etiology. In the majority of cases, surgical correction will not reduce the risk of sudden incapacitation to acceptable levels; in some cases it may even increase the risk.

Aortic stenosis

Moderate or severe stenosis is unacceptable for unrestricted flying. Applicants with mild stenosis of the aortic valve can be considered for medical certification if the following conditions are met.

- The mean systolic pressure gradient across the aortic valve is shown to be less than 30 mmHg by echocardiography or Doppler imaging, or less than 20 mmHg by invasive hemodynamic studies.
- The cross-sectional valve area is not less than 1.2 cm(2).
- There are no related symptoms.
- Holter monitoring reveals no significant dysrhythmia such as atrial fibrillation or sustained ventricular tachycardia.
- The result of a submaximal treadmill exercise test is satisfactory(A satisfactory test is obtained by achieving 8 Mets (end of stage 3) with the Bruce protocol and no ischemia, significant arrhythmia or disabling symptoms.).

Aortic regurgitation

Pure isolated regurgitation is uncommon; therefore, assessment of a applicants with aortic regurgitation will likely include consideration of any associated disorders. Only mild, asymptomatic aortic regurgitation can be considered acceptable in applicants and only if the following criteria are met.

- The pulse pressure is less than 55 mmHg and the diastolic pressure is greater than 65 mmHg.
- The end-diastolic internal diameter of the left ventricle is less than 55 mm. As measured by two-dimensional echocardiography.
- The result of a treadmill exercise test is satisfactory(A satisfactory test is obtained by achieving 8 Mets (end of stage 3) with the Bruce protocol and there is no ischemia, significant arrhythmia or disabling symptoms.).

Follow-up for aortic valve disease

Because of the increased risk of endocarditis with aortic valve disease, prophylaxis with antibiotics must be strictly followed. Follow-up should include a yearly assessment with at least 2-D and full doppler echocardiography to monitor any progression.

Mitral stenosis

In view of its progressive nature and its propensity for thromboembolic complications, mitral stenosis will disqualify most applicants. Only very mild mitral stenosis with a cross sectional mitral valve area > 1.2 cm2 and stable normal sinus rhythm may be considered.

Mitral regurgitation

The cause of mitral regurgitation can alter the prognosis; therefore, an assessment of this condition should include information about the likely underlying cause as well as an estimate of the severity of the lesion. Mild and asymptomatic mitral regurgitation may be acceptable in applicants if the following conditions are met.

- Mitral stenosis is absent.
- The diameter of the left atrium is less than 4.5 cm.
- Atrial dysrhythmia such as fibrillation or other supraventricular tachycardia is absent, as determined by Holter monitoring.
- There is no history of embolism.
- Significant coronary artery disease is absent according to the results of a submaximal treadmill exercise test.

Mitral valve prolapse

Mitral valve prolapse has a wide spectrum of severity. Most cases are mild and detectable either by the presence of a midsystolic click and/or soft murmur or by echocardiographic changes. Medical

certification may be considered if the following conditions are met.

- There is no history of embolism or transient cerebral ischemia.
- There is no relevant family history of sudden death.

If the left atrial size is increased or if there is redundancy of the mitral valve leaflets, then a treadmill exercise test and 24 hour Holter-monitoring will be required as these findings can be markers of increased risk.

Follow-up for Mitral valve disease

Annual follow-up for mitral valve stenosis and/or regurgitation should include, in addition to a thorough history and physical examination, 2D and doppler echocardiography and 24 hour Holter-monitoring. The follow-up for mitral valve prolapse will be determined on a case-by-case basis depending on the degree of prolapse and any associated findings.

Surgical repair or replacement of valves

Following surgical reconstruction (valvuloplasty) of the mitral valve a licence holder may be considered fit if there are no significant residual hemodynamic or clinical abnormalities.

In view of the risk of thromboembolism, associated cardiac dysfunction, valve failure and bleeding secondary to anticoagulation, prosthetic valvular replacement will disqualify most applicants. Where the cumulative risk of these factors can be shown to be less than 2% per year and thus comparable to the acceptable level of risk with other conditions, an applicant may be considered fit.

CONGENITAL HEART DISEASE

Atrial septal defect

Licence holders with small sinus venosus or secundum defects (pulmonary/systemic flow ratio less than 2:1 and normal right heart pressures) as determined by doppler echocardiography or cardiac catheterization and without recurrent atrial arrhythmias need not be restricted from flying. Applicants with partial atrioventricular canal defects (primum type atrial septal defects) cannot have more than mild mitral regurgitation, and they must meet the same requirements for flow ratios and atrial arrhythmias. Applicants with surgical correction of larger defects may be medically certified if they meet the same requirements.

Coarctation of the aorta

Applicants with surgically corrected coarctation of the aorta should be considered individually. The age at the time of the surgical correction will be a major determinant in the decision about medical certification of a licence holder since the risk of sudden death and incapacitation due to cerebrovascular accidents is markedly increased in people who undergo surgery after the age of 12 years. In all cases the blood pressure at rest and in response to exercise must be normal.

Pulmonary stenosis

The major determinant of risk in applicants with this condition is the severity of the stenosis. Those with mild pulmonary stenosis and normal cardiac output will be considered for licensure provided the following criteria are met.

- The peak systolic pressure gradient across the pulmonary valve is less than 50 mmHg, and the peak systolic right ventricular pressure is less than 75 mmHg, as determined by echocardiography or cardiac catheterization.
- Symptoms are absent.
- The result of a submaximal treadmill exercise test is normal.

Applicants with pulmonic stenosis corrected by surgery or balloon valvuloplasty will be considered fit if there is no dysrhythmia and if the hemodynamic parameters are not worse than those described above.

Ventricular septal defect

A applicant's eligibility for medical certification will depend on the size of the ventricular septal defect as indicated by the hemodynamic consequences. In the absence of surgical correction an applicant may be considered for licensure if the following conditions are met.

- The heart size is normal.
- The pulmonary/systemic flow ratio is less than 2:1, as determined by echocardiography or cardiac catheterization.

- The pressures in the right heart are normal.

An applicant with a surgically corrected ventricular septal defect may be considered for medical certification if the same conditions are met as for no surgical intervention, and in addition.:

- No dysrhythmias or high-grade conduction disturbances are detected by Holter monitoring.
- The response to a submaximal treadmill exercise test is normal.

Tetralogy of Fallot

The unoperated condition with cyanosis is incompatible with medical certification. Individuals who undergo repair of Tetralogy of Fallot may be considered for medical certification if the following conditions are met:

- Normal arterial oxygen saturation.
- Normal heart size.
- Right ventricular systolic pressure less than 75 mmHg and peak RV/PA gradient less than 50 mmHg.
- Residual interventricular shunt not more than 1.5:1.
- No dysrhythmias or high-grade conduction disturbances by Holter monitoring.
- Normal performance on a treadmill exercise test.

Transposition of Great Arteries

The unoperated condition is incompatible with medical certification with the sole exception of congenitally corrected transposition without any other associated cardiac abnormalities.

Applicants with atrial switch corrective procedures for transposition of the great arteries are unlikely to be eligible for medical certification because of the increasing propensity to atrial arrhythmias with passing years, even with technically excellent surgery. Applicants who have had arterial switch operations will need to be considered separately when this cohort begins to reach adulthood.

Inflammatory heart disease

Active pericarditis and/or myocarditis is medically disqualifying. Medical certification may be considered after satisfactory recovery if there are no adverse sequelae. (i.e., the results of a cardiovascular examination are normal).

CARDIOMYOPATHY

Obstructive hypertrophic cardiomyopathy poses a significant risk for sudden incapacitation and generally disqualifies an applicant from flying regardless of whether there has been surgical treatment. Applicants with minor asymmetric hypertrophy will be considered individually based on the degree of outflow obstruction and the nature of any arrhythmias.

Nonhypertrophic cardiomyopathies dilated or congestive, in their active phase disqualify an applicant from flying. However, recertification may be considered after recovery if the following conditions are met:

- Symptoms are absent.
- Exercise tolerance is satisfactory. *(A satisfactory test is obtained by achieving 8 Mets (end of stage 3) with the Bruce protocol and there is no ischemia, significant arrhythmia or disabling symptoms.)*
- There is no need for medication.
- Left ventricular function as determined by echocardiography is satisfactory, i.e. EF > 40%.
- The risk of thromboembolism and (if applicable) the risk of hemorrhage secondary to anticoagulation are acceptable.

CARDIAC TRANSPLANTATION

Cardiac transplantation should disqualify an applicant from medical certification. Selected individuals (i.e. experienced pilots) may be considered 2 years after a successful transplantation.

Chapter 3: Dysrhythmias

All applicants with dysrhythmias should be evaluated with two questions in mind: What is the nature of the disability produced by a given arrhythmia (i.e., how incapacitated is the pilot when the dysrhythmia occurs?) and what is the underlying condition of the heart (i.e., is structural heart disease present?). Both questions must be answered before a decision can be made about an applicant's fitness to fly.

SUPRAVENTRICULAR DYSRHYTHMIAS

Supraventricular tachydysrhythmias may accompany self-limited illnesses (e.g., pneumonia) or treatable conditions (e.g. hyperthyroidism). In such cases the need to restrict flying will be only temporary.

Applicants in whom treatment with an antiarrhythmic agent is successful need not be restricted from flying. Successful use of ablation therapy should be confirmed with repeat electrophysiologic study 3 months later. Applicants who undergo AV nodal ablation of the slow pathway are more likely to be reconsidered favourably because of the lower risk of development of heart block.

SINUS NODE DYSFUNCTION

Isolated sinus node dysfunction including sinus bradycardia may occur in healthy people, particularly those involved in vigorous exercise programs. Such a finding (a consequence of high vagal tone) need not necessarily be considered an abnormality. Provided the dysfunction does not interfere with mental function, the licence holder need not be restricted from flying. Where there is concern (e.g. extreme bradycardia) a thorough symptom history should be followed by Holter-monitoring and a treadmill exercise test. Even in a healthy applicant no R-R interval should exceed 4 sec during sleep or 3 sec while awake.

ATRIAL FIBRILLATION

There are 3 major concerns in the assessment of the risk of incapacitation in an individual with atrial fibrillation. The first is the hemodynamic effect of the arrhythmia itself. The second is the risk of embolism and the third is the risk of bleeding as a consequence of anticoagulation. Since risk is additive the aggregate risk must remain within acceptable limits. Therefore it is possible that flying may be allowed for selected aircrew depending on their condition and the effect of treatment. The lowest risk is seen in those below 65 years of age who have intermittent or chronic, lone atrial fibrillation, (i.e. no identifiable cause of the arrhythmia and no underlying structural heart disease). Annual follow-up in such cases should include 48 hr Holter monitoring. Older licence holders with structural heart disease generally have a cumulative risk of embolism and bleeding secondary to anticoagulation that exceeds the limit for medical certification.

PRE-EXCITATION SYNDROMES

Not all cases of Wolff-Parkinson-White (the most common type of pre-excitation) are associated with incapacitating dysrhythmias. The risk of incapacitating symptoms in people who have never had tachycardia is low but is not known with any precision. Applicants with ECG indication only, whether chronic or intermittent, and no history of palpitations may be fit to fly if their response to a treadmill exercise test is normal in all respects particularly if evidence of pre-excitation is lost at accelerated heart rates. Such individuals are unlikely to conduct at a dangerously high rate if in atrial fibrillation. Electrophysiologic studies are not required in such cases.

Medical certification in a restricted capacity may be considered 3 months after a symptomatic episode of tachycardia has been controlled with medication. Applicants in whom accessory pathway connections have been ablated surgically or by catheter techniques are considered fit provided repeat electrophysiologic studies 3 months after surgery confirm a successful intervention.

VENTRICULAR DYSRHYTHMIAS

The main concern with ventricular dysrhythmias is the underlying condition of the myocardium. A careful assessment should be done to determine the presence of structural heart disease. If the myocardium is normal, ventricular ectopy should be judged on the basis of the disability produced and, to a lesser extent, on the presence or absence of complex forms. Although the complexity of premature ventricular beats is poorly correlated with

risk in the presence of normal myocardial tissue, the appearance of multiform or repetitive forms of ventricular ectopy (i.e., couplets, runs) should indicate the need for a thorough cardiac examination since these and other high grade forms of ectopy are more commonly seen in association with structural heart disease. If the ventricular ectopic beats have a LBBB pattern particularly with a vertical axis, right ventricular dysplasia should be ruled out by either invasive (ventriculography) or non-invasive (echo or radionuclide scintigraphy) tests.

Exercise-induced ventricular tachycardia can occur in healthy people. These events are invariably self-terminating, and, even with electrophysiologic provocation, sustained ventricular tachycardia is not seen. Most people have one episode only. Medical certification need not be restricted in such cases unless there are recurrent episodes. In some cases catheter ablation can be curative.

CONDUCTION DISORDERS

First-and-second-degree (type 1) atrioventricular conduction delay can be seen during rest (particularly sleep) in healthy people who engage in vigorous exercise. High grade atrioventricular block should be investigated to rule out heart disease and to determine the risk of progression to complete heart block.

BUNDLE BRANCH BLOCK

Left bundle branch block and right bundle branch block of recent onset, indicate the need for a thorough cardiovascular examination to rule out heart disease, especially ischemic heart disease. Isolated right bundle branch block and left hemiblocks that are longstanding are generally benign.

CARDIAC PACEMAKERS

The reliability and safety of implantable cardiac pacemakers is well established and continues to improve. Conditions in which there is little or no structural heart disease and for which the requirements for a pacemaker are intermittent need not disqualify a licence holder from flying. Each case will need to be considered individually and not before 3 months after successful implantation.

IMPLANTED CARDIAC DEFIBRILLATORS

Implanted cardiac defibrillators are permitted only with a restricted medical certification. Such restricted certification will not be considered before completion of a trial period of at least 2 years. During this time defibrillator function and cardiac response must be carefully monitored to ensure dysrhythmias are promptly corrected with no side effects or sequelae.

Chapter 4: Vascular Disorders

ANEURYSM

Untreated aneurysms, even if asymptomatic are unlikely to be compatible with medical certification unless it can be demonstrated that the risk of rupture is less than 2% per year. The presence of an aneurysm (e.g. in the abdomen of a middle-aged or older pilot) raises concerns about the presence of co-existing conditions, particularly coronary artery disease. Prosthetic graft replacement of diseased aortic aneurysms with no other evidence of risk will be considered on an individual basis.

ASYMPTOMATIC CAROTID BRUIT

Since the presence of a carotid bruit may indicate severe stenosis, it should lead to a carotid doppler examination. Significant stenosis (>50%) even asymptomatic is associated with a >33% risk of coronary events over 4 years and is therefore medically unacceptable.

ARTERIAL THROMBOSIS

Individuals who have sustained an isolated, arterial thrombosis will be considered on an individual basis. Of particular concern are thromboses related to coagulopathies or other chronic predisposing conditions.

VENOUS THROMBOSIS

An isolated episode of deep venous thrombosis need not preclude medical certification provided there are no chronic predisposing conditions, and a minimum of 6 months have elapsed since the episode. Applicants with recurring episodes or with known predisposing factors will be considered on an individual basis only after 12 months have elapsed since the last episode and their risk of recurrence is lowered by satisfactory anticoagulation. The latter requires demonstration of therapeutic INR levels over a recent 1 month period.

PULMONARY EMBOLISM

Applicants with an isolated episode of pulmonary embolism, without predisposing conditions for recurrence can be considered for relicensure after an interval of 6 months, provided there is no disabling, residual pulmonary hypertension and the risk of venous thrombosis and pulmonary embolism is decreased by appropriate treatment to an acceptable level.

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DIABETES

CANADIAN GUIDELINES FOR THE ASSESSMENT OF MEDICAL FITNESS IN PILOTS, FLIGHT ENGINEERS AND AIR TRAFFIC CONTROLLERS, WITH DIABETES MELLITUS

DEDICATED TO THE MEMORY OF DR. GERALD S. WONG

Foreword

Since the discovery of insulin in Toronto in 1923 by Banting & Best great progress has been made in the treatment of diabetes mellitus. In the last ten years control of this condition has improved dramatically with the development of patient operated computer chip glucose meters and patient education. Blood tests to assess long term control such as Hb.A1.C. also have made it much easier to make alterations to diet, exercise, insulin or hypoglycemic medication dosage for optimum control.

This enormous progress in the management of the disease together with an increase in the number of insulin and oral hypoglycemic treated diabetics prompted Transport Canada's Civil Aviation Medicine Branch to reexamine its policies on diabetes mellitus. To this end a one day workshop was held on April 8th 1992 in Ottawa to review the subject in the context of the modern aviation environment.

These guidelines are based on the deliberations at that meeting. Physicians are reminded that this document should be used as a guide only and it should not be confused with the medical standards for aviation personnel published by Transport Canada Aviation (TP 195). Any specific questions should be directed tothe nearest regional aviation medical office of the Civil Aviation Medicine Branch, Transport Canada (Appendix).

To the late Dr. Gerald S. Wong, for his special assistance in the early stages and for co-chairing the workshop, I am eternally grateful.

To Dr. James Wallace, Senior Consultant, Operations Policy and Standards and to Dr. Robert Depuis, Internal Medicine Consultant to the Aviation Medical Review Board, who shared the task of writing and editing the rest of this document, my gratitude for successfully completing a very difficult task.

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Introduction

The practice of aeromedical certification of pilots and air traffic controllers with diabetes in most Contracting States of the International Civil Aviation Organization, including Canada, has been fairly consistent and has not changed for many years. Applicants with diabetes whose condition can be controlled by dietary measures alone are permitted to fly and control air traffic. All others requiring medication for this common disorder are assessed as "unfit" for such activities.

The Canadian Charter of Rights and Freedoms which was enacted in 1982 has a number of human rights provisions, one of which states that "no person shall be discriminated against on the basis of disability". Given this constitutional background there have been an increasing number of challenges in the Courts and Human Rights Tribunals on refusals to issue licences on medical grounds including diabetes mellitus (DM).

The Civil Aviation Medical Branch (CAM) of Transport Canada is the medical body which advises the Minister of Transport on medical fitness to fly or control air traffic. CAM decided that the time had arrived to review its position on all types of diabetes, given the apparent improvement in the treatment and control of the disorder.

In order to address this issue, a conference was convened in Ottawa on April 8, 1992. Present at this conference were six eminent specialists in DM, members of CAM headquarters and regional medical staff, members of the Aviation Medicine Review Board (AMRB), medical representatives from the airline industry, the U.S. Federal Aviation Administration and the Canadian Diabetes Association.

This document reflects the proceedings of that one day conference.

The recommendations in this document may cause concern to some physicians, but it is felt that with the implementation of these recommendations meaningful data in this area can be developed without jeopardizing flight safety.

Guidelines

One of the major considerations in medically certifying diabetics who are insulin treated or who require oral hypoglycemics agents, is the risk of subtle or sudden incapacitation. In the diabetic person this would be most likely caused by hypoglycemia. Let us therefore consider the metabolic condition of hypoglycemia.

Hypoglycemia:

Hypoglycemia is usually considered to be a blood glucose concentration in the range below the level at which symptoms could be expected to occur.

In the person without diabetes, blood glucose is kept within a fairly narrow range by a homeostatic mechanism regulated by glucose intake and storage, insulin, glucagon, catecholamines, cortisol and growth hormone. In insulin treated diabetes mellitus (ITDM) insulin is provided from an exogenous source so fine control of this delicate homeostasis has been compromised. Hypoglycemia may result from too much insulin, too little glucose, an over-expenditure of energy or any combination of the above.

Diabetes specialists officially define hypoglycemia as being either:

(a) when the plasma glucose falls below 2.8 mmol/L (50 mg./dl) or

(b) when symptoms of hypoglycemia occur.

The symptoms and signs of hypoglycemia can be broken down into two main groups:

(a) Neurogenic

- Weakness
- Palpitations
- Tremor
- Sweating
- Hunger

(b) Neuroglycopenic

- Cognitive impairment
- Mental status changes
- Abnormal behaviour
- Irritability
- Seizure activity

Results from the multicentred Diabetes Control and Complications Trial revealed that among an intensive insulin treated group of patients with diabetes, the incidence of hypoglycemic reactions is relatively common. Severe hypoglycemia is definitely related to the degree of glycemia control and the effectiveness of the physiological counter regulatory mechanisms.

Studies have also demonstrated that patients with diabetes who are poorly controlled tend to recognize hypoglycemia at higher blood glucose levels than do intensively insulin treated diabetic individuals, who may not recognize the hypoglycemic reaction until their blood glucose level is much lower. This is a result of blunting of the counter regulatory mechanisms. This situation which exists among the intensively treated group is termed by diabetologists ***hypoglycemia unawareness***.

It is apparent then that the unpredictability of hypoglycemia could be a major aviation safety hazard in the cockpit or the air traffic control worksplace.

As in many other areas of risk assessment in aviation medicine, (e.g. cardiovascular, neurological), a level at which the degree of risk can be considered acceptable must be sought. This degree of risk should not be much in excess of the risk of the same condition occurring in a completely healthy person. Most recently in Canada, for conditions such as coronary events or seizure following head injury, a risk of 2% per annum or less has been considered acceptable.

Table 1 attempts to address the question of risk of hypoglycemia. Those Insulin treated diabetics who fell into the high risk group would not be considered for any form of licence, whereas those falling in the low risk group could be considered.

With this in mind the conference group has proposed the following guidelines for the medical certification of pilots, air traffic controllers and flight engineers with diabetes. It must be understood that these are **only** guidelines and that each case will be reviewed individually by the Aviation Medical Review Board. Of particular concern are the neuroglycopenic effects of hypoglycemia and the effect they have on information processing, which is an extremely important aspect of both piloting and air traffic controlling tasks.

Table 1

HYPOGLYCEMIA RISK AMONG INSULIN USERS

HIGH RISK	LOW RISK
	• Stimulated C-Peptide levels > 25% Normal*
• Previous hypoglycemic reactions requiring intervention	• No previous hypoglycemic reactions requiring intervention
• Symptoms and signs of neuroglycopenia	
• Unstable glycemia control as measured by: (a) Glycated Hb (pt./upper norm ratio > 2.0) (b) Blood glucose metering 10% values < 5.5 mmol/L	• Stable control as measured by: (a) Glycated Hb (pt./upper norm ratio < 2.0) (b) Blood glucose metering 90% values > 5.5 mmol/L
• Inadequate self = monitoring	• Adequate self = monitoring with memory chip glucose meter
• Poor diabetes education and understanding	• Good diabetes education and understanding
• Evidence of hypoglycemia unawareness	• No evidence of hypoglycemia unawareness
• Negative attitude to self care	• Positive attitude to monitoring and self care

* *C-peptide is an indicator of beta cell activity. Most IDDM's are C-peptide negative.*

Non Insulin Treated Applicants With Diabetes Mellitus (DM)

1. Those applicants who can control their blood glucose by diet alone may be considered fit for all categories of licence, provided they have no cardiovascular, neurological, ophthalmological or renal complications of DM which could result in sudden or subtle incapacitation while exercising the privileges of their licence.
2. Applicants who require oral hypoglycemic agents to control their blood glucose may be considered for medical certification providing certain criteria can be met.

These criteria are:

(a) No episode of hypoglycemia requiring intervention by others in past 12 months.

(b) The Applicants must have taken the hypoglycemic agent for a minimum of 6 months (3 months in the case of metformin and the thiazolidinediones), and the dosage should have been stable for at least 3 months.

(c) There must be evidence of stable blood glucose control for at least 3 months as measured by;

(i) Glycated Hb (patient/upper normal ratio less than 2.0)

(ii) Blood glucose metering shows 90% of values greater than 5.5 mmol/L.

(d) No neurological, cardiovascular, ophthalmological or renal complications of DM that could result in sudden or subtle incapacitation while exercising the privileges of the licence.

(e) Blood glucose monitoring will be carried out using a memory chip glucose meter. This equipment together with a readily absorbable source of glucose will be carried by the applicant while exercising the privileges of the licence.

(f) A vision care specialist assessment is required on initial application and every year thereafter.

(g) A cardiovascular assessment to include an exercise electrocardiogram is required at the age of 40 and then 5 yearly to age 50. After the age of 50 it should be completed every two years. A resting ECG will be required yearly.

Insulin Treated Applicants With Diabetes Mellitus (ITDM)

This group will include all Type I DM applicants and those Type II DM applicants who require insulin in addition to dietary management.

The major issue in this group, particularly in the Type I (IDDM) applicants, is assessing the risk of hypoglycemia. An attempt has been made based on the opinions of the diabetologists at the conference to classify low risk and high risk ITDM (see table #1).

It is conceivable that an applicant who meets all the criteria to be classified as low risk could be considered for a Category 4 (ultralight/glider) or a Category 2 (ATC) medical certificate. (See appendix 1 & 2). All Category 2 applicants should be referred to the Senior Consultant, Operations in Ottawa prior to a medical certification recommendation.

Until data has been gathered from the Category 2 group (ATC) both in Canada and from other jurisdictions, applicants for Category 3 with ITDM will be considered unfit. An exceptionally low risk ITDM who already holds a Category 1, may be considered for medical certification restricted to "as or with co-pilot".

Appendix 1

Standard for Category 4
(Glider and Ultralight)

An **unstable** metabolic disorder in the case of diabetes mellitus shall include any of the following.

- Any history within the past 2 years of hypoglycemia requiring the intervention of another person or hypoglycemia in the absence of warning symptoms (hypoglycemic unawareness).
- Inadequate blood glucose control as indicated by blood glucose results or glycated hemoglobin results.
- Significant visual, neurological or cardiovascular complications.

If an applicant with diabetes has none of the above, he/she may hold a Category 4 MC provided the following requirements are also met:

(a) A full medical examination report, conducted by a designated CAME is submitted to the RAMO.

(b) A full report from a specialist in Endocrinology or Internal Medicine is submitted to the RAMO at first application and at yearly intervals thereafter.

Appendix 2

Air Traffic Controllers (ATCs)

Permission by special flexibility may be granted to ATCs who have developed ITDM but are in the low risk group.

Glucose management during working hours:

All ITDM shall identify themselves as such to the shift supervisor. Individual ATCs with ITDM shall have appropriate medical supplies available at all times in the workplace.

Supplies shall include:

- Blood glucose monitor with a memory chip.
- Blood sampling lancets.
- A source of readily absorbable glucose.
- Insulin with syringes or pump.

Blood glucose levels will be tested:

- 30 minutes prior to shift commencement.
- Every 2 hours during shift.
- If because of operational requirements the 2 hourly blood glucose cannot be done then the individual must consume at least 10 gm glucose as a snack or drink.
- No two consecutive blood glucose estimations may be substituted by a snack.
- The shift supervisor should be given evidence periodically that blood glucose is well controlled.

Precautions:

If the blood glucose (BG) falls below 3.5 mmol/L, the individual shall stop work and take at least 10 gm of readily absorbable glucose. If at recheck within 30 min., the BG is <5.5 mmol/L then further glucose shall be taken until BG is 5.5 mmol/L or greater, at which time the individual may resume shift.

If BG is between 5.5 and 16.5 mmol/L no action is required.

If BG is between 16.5 and 22 mmol/L, take appropriate action to lower BG. (i.e. with insulin and/or exercise). Recheck BG in 30 minutes.

If BG > 22 mmol/L then individual shall stop work and take corrective action (insulin), and then recheck BG every 30 minutes until BG < 22 mmol/L before resuming work. They should seek advice from a physician.

If the controller experiences blurring of vision he/she should cease work and check BG.

- There should also be a set of instructions for shift supervisors.

Appendix 3

Selection Conditions for Insulin Treated Diabetes Applicants (ITDM)

– Category 4 R.P.P. & Student Pilot (Aeroplane)

– Category 2 Air Traffic Controller (Restricted)

– Category 1 (Restricted) Air Line Transport Pilot (Aeroplane)

ITDM applicants will be considered for medical certification provided the following conditions are met:

- No recurring hypoglycemic episodes requiring the intervention of another party during the past 5 years.
- 1 year stable blood glucose control as measured by:
  - glycated hemoglobin (A1 or A1c levels) (patient/upper level normal ratio < 2.0)
  - 90% blood glucose values > 5.5 mmol/L.
- Must demonstrate good diabetes education & understanding and have a positive attitude towards monitoring & self control.
- No evidence of *hypoglycemia unawareness*.
- Medical evaluation by a specialist in diabetes every 3 months, to include glycated hemoglobin (A1 or A1c levels) levels and a log of blood glucose levels.
- The initial medical report should include specialist reports from:
  a) an ophthalmologist
  *b) a cardiologist (to include a Treadmill Exercise Test - TXT)
  *c) a neurologist
  *d) a nephrologist

all of these reports should be negative in terms of significant complications of diabetes.

- Submission of a routine civil aviation medical examination report including a resting ECG at no less than 12 monthly intervals.
- A report from a vision care specialist every 2 years.
- A report from a cardiologist (to include a TXT) every 2 years over the age of 40.

Note: All ITDM applicants who have achieved medical certification will be monitored by a single physician within the CAM organization in order to maintain consistency and an adequate data base.

* *Reports a, b and c may be in the form of a comprehensive report from a specialist in internal medicine.*

Appendix 4

Selected ITDM Applicants who meet Category 4 R.P.P. & Student Pilot (Aeroplane) Medical Certification Conditions

BLOOD GLUCOSE MANAGEMENT PRIOR TO AND DURING FLIGHT

Note: Blood Glucose levels will be required to be maintained at **higher than optimal values** prior to and during flight, in order to minimize the risk of hypoglycemia. This may have an effect on the long term health of the individual. **The applicant must be made fully aware of this.**

1. Individuals with ITDM shall maintain the appropriate supplies for blood glucose management, which shall include:

a) A reliable calibrated glucose meter with memory chip and appropriate blood sampling equipment.

b) A supply of 10 gm. portions of readily absorbable carbohydrate, appropriate to the duration of flight.

2. Prior to flight blood glucose must be greater than 6.0 mmol/L. Blood glucoses must be monitored every 30 minutes during flight. If the blood glucose falls below 6.0 mmol/L then 10 gms. carbohydrate should be ingested.

3. If, for operational reasons, the in-flight 30 minute blood glucose measurement cannot be done, then 10 gms. carbohydrate must be ingested, however, this shall not be done on two consecutive 30 minute occasions without a blood glucose measurement.

4. The blood glucose should be measured 30 minutes prior to landing and if below 6.0 mmol/L then 10 gms. carbohydrate must be ingested.

5. If the blood glucose should exceed 15 mmol/L then the individual should land as soon as possible and take corrective therapeutic measures.

OTHER POLICIES

EAR, NOSE AND THROAT

1. **Hearing:**

   Audiogram if doubt raised by screening examination. Acceptable limits:

   35 db at 500 Hz
   1000 Hz
   2000 Hz
   50 db at 3000 Hz

   If hearing doesn't meet standard on audiogram the applicant will likely need Practical Hearing Test.

2. **Drum Perforation:**

   A single dry perforation is acceptable. An acute perforation will result in being unfit until hearing and the tympanic membrane recovers.

3. **Otitis media:**

   Unfit until recovered

4. **Sinusitis:**

   Unfit until recovered.

5. **Menière's Disease:**

   Disqualifying. ENT consult will be needed to confirm diagnosis.

6. **Labyrinthitis:**

   Unfit while acute. ENT consult will be needed in non-infective vestibular disorders.

OPHTHALMOLOGY

1. **Myopia:**

   Initial medical Category 1,2 or 3 – need glasses prescription if uncorrected visual acuity is 6/60 (20/200) or worse.

2. **Cataracts:**

   Unfit when vision in affected eye no longer meets standard.

3. **Intraocular Lenses:**

   Unfit for 6 weeks following surgery. Full report from attending ophthalmolgist.

4. **Colour Vision Deficiency:**

   If applicant fails pseudoisochromatic plate test, he will be given restricted medical certificate (Daylight only, 2 way radio required at controlled airports). Those who fail plate test may try a colour lantern test or Farnsworth D-15.

5. **Contact Lenses:**

   Can be approved for all categories:

6. **Refractive Surgery:** (See guidelines)

RESPIRATORY

1. **Pneumonia:**

   Unfit until fully recovered.

2. **COPD / Emphysema:**

   Usually disqualifying if it requires active treatment. Pulmonary function tests and arterial blood gases or oxymetry usually required. Consultation with a respirologist or internist is usually required.

3. **Asthma:**

   Remote childhood asthma is not disqualifying. As an adult individual assessment is made on the basis of severity of disease, type and amount of medication required. Full history, pulmonary function tests and attending physician or respiratory specialist report usually required.

GASTROINTESTINAL DISEASE

1. **Acid Peptic Disease:**

   Dyspepsia or esophagitis treated with antacids alone is acceptable. Long term maintenance with H2 antagonists is acceptable if there are no significant side - effects.

2. **Gastric / Duodenal Ulcer:**

   Disqualifying while ulcer is present and under active treatment. Long term maintenance with H2 antagonists is acceptable if no significant side - effects.

3. **Hernia:**

   Significant hernias are disqualifying until the hernia is repaired. If there is any question about the significance of a hernia a surgical consultation is required.

4. **Cholelithiasis / Cholecystitis:**

   Cholecystitis is disqualifying. Presence of stones with a history of symptoms is disqualifying. Asymptomatic cholelithiasis as an incidental finding may be acceptable.

GENITOURINARY DISEASE

1. **Renal Calculi:**

   Single episodes my be acceptable after recovery if IVP or ultrasound shows no stones present, and a metabolic work-up is normal. Repeated episodes will need a full work-up and individual assessment.

2. **Cancer of the Prostate:**

   May be acceptable after treatment. Will need full report from urologist or oncologist. Follow-up reports including PSA will likely be required.

METABOLIC DISEASE

1. **Diabetes Mellitus:** (See Section D1 -D10)
2. **Thyroid Disorders:**

   Hypothyroidism is acceptable if adequately treated and stabilized. Hyperthyroidism requires full report from internist or endocrinologist and treatment stabilization prior to assessment.

MUSCULOSKELETAL DISEASE

1. **Locomotor Dysfunction:**

   Includes all amputations, malformation, arthritis and loss of function. All will be assessed on an individual basis. Full description is required. Practical Flight Test may be required.

PSYCHIATRIC DISEASE

1. **Anxiety Disorder:**

   Disqualifying if requiring active treatment with tranquilizers. Will likely require a psychiatric consultation.

2. **Depression:**

   Ongoing depression is disqualifying condition. May be recertified after full recovery and cessation of treatment. Waiting period prior to recertification will be individually assessed. Report from attending physician or psychiatrist likely required.

Note: *Applicants who have been treated for a depressive illness and who are on maintenance or prophylactic therapy with non-sedating selective serotonin reuptake inhibitors (SSRIs) may be considered for medical certification on an individual basis after review by the CAM Aviation Medicine Review Board.*

3. **Substance Abuse / Dependence:**

Disqualifying. Once "recovering", an individual assessment to assess risk of relapse. Restricted category may be recommended. Continued abstinence is the key to medical recertification.

MALIGNANCY

1. Malignancy:

Each case assessed individually. Active chemotherapy is disqualifying. Will need: pathology report and report from oncologist to include staging, treatment, prognosis and follow - up plans.

HIV /AIDS

1. Applicants who are HIV seropositive may be considered for medical certification on an individual basis. The major concern is the development of HIV related psychiatric or neurological complications. CD-4 cell counts and "viral load" measurements will be taken into account. For further information contact your RAMO.

REQUIREMENTS FOR MEDICAL CERTIFICATION FOLLOWING REFRACTIVE SURGERY

Prior to medical certification after corneal refractive surgery the following conditions must be met. These conditions apply to all medical categories and to initial and subsequent treatments. The emphasis is on the stability of vision and refraction.

PHOTOREFRACTIVE KERATECTOMY (PRK) and LASER ASSISTED IN-SITU KERATOMEULESIS (LASIK)

- Minimum intervals between withdrawal of eye drops after refractive surgery and medical certification for pre-operative refractive error of :

  Up to 6.00 Dioptres spherical equivalent:
  PRK – 3 months
  LASIK – 3 months

  6.00 to 10.00 Dioptres spherical equivalent:
  PRK – 6 months
  LASIK – 3 months

  Greater than 10.00 Dioptres spherical equivalent:
  PRK – 6 months
  LASIK – 6 months

- Visual acuity which meets the required standards
- No "haloing", haze or night vision problems
- Refraction and visual acuity remaining stable, as demonstrated by refraction and visual acuity measurements at 3 and 6 months post-surgery
- No significant reduction in contrast sensitivity measurements
- No ongoing medical treatment of the eyes
- Completion of a specific questionnaire by a vision care specialist
- Follow-up report by a vision care specialist 12 months after medical certification.

RADIAL KERATOTOMY (RK)

- Minimum intervals between withdrawal of eye drops after refractive surgery and medical certification for pre-operative refractive error of :

  Up to 6.00 Dioptres spherical equivalent:
  3 months

  6.00 to 10.00 Dioptres spherical equivalent:
  6 months

  Greater than 10.00 Dioptres spherical equivalent:
  6 months

- Visual acuity which meets the required standards
- No haze or night vision problems
- Refraction and visual acuity remaining stable, as demonstrated by refraction and visual acuity measurements at 3 and 6 months post-surgery
- No significant diurnal variation in visual acuity
- No ongoing medical treatment of the eyes
- Completion of a specific questionnaire by a vision care specialist

May 1999

PHOTOREFRACTIVE KERATECTOMY (PRK) and LASER ASSISTED IN SITU KERATOMEULESIS (LASIK)

PATIENT'S NAME: _____ FILE No._____

Date of Surgery:_____ Surgical Technique: _____

Number of treatments: _____ Size(s) of Ablation Zone(s):_____

UNCORRECTED ACUITY	REFRACTION & CORRECTED ACUITY
Pre-operative data:	
OD_____	_____ = _____
OS _____	_____ = _____
3 Months Post PRK:	
(may be completed by an Optometrist)	
OD_____	_____ = _____
OS _____	_____ = _____
6 Months Post PRK:	
(may be completed by an Optometrist)	
OD_____	_____ = _____
OS _____	_____ = _____

Are there any of the following:

Glare sensitivity or "haloing" ..... Yes___ No___

Night vision difficulty ..... Yes___ No___

Diurnal variation of vision ..... Yes___ No___

Use of ocular medication ..... Yes___ No___

Corneal haze ..... Yes___ No___

Loss of contrast sensitivity/acuity (this has potentially serious implications in the aviation environment) ..... Yes___ No___

Signature of attending Ophthalmologist/ Optometrist _____

Date: _____ Phone: ( ) _____

MAY 1999

RADIAL KERATOTOMY (RK)

PATIENT'S NAME: _____ FILE No._____

Date of Surgery:_____ Surgical Technique: _____

Number of treatments: _____

	UNCORRECTED ACUITY	REFRACTION & CORRECTED ACUITY	KERATOMETRY
Pre-operative data:			
OD	_____	_____ = _____	_____
OS	_____	_____ = _____	_____
3 Months Post-RK: (may be completed by an Optometrist)			
OD	_____	_____ = _____	_____
OS	_____	_____ = _____	_____
6 Months Post-RK: (may be completed by an Optometrist)			
OD	_____	_____ = _____	_____
OS	_____	_____ = _____	_____
12 Months Post-RK: (may be completed by an Optometrist)			
OD	_____	_____ = _____	_____
OS	_____	_____ = _____	_____

Are there any of the following:

Glare sensitivity or "haloing" ..... Yes___ No___

Night vision difficulty ..... Yes___ No___

Diurnal variation of vision ..... Yes___ No___

Use of ocular medication ..... Yes___ No___

Corneal haze ..... Yes___ No___

Signature of attending Ophthalmologist/ Optometrist _____

Date: _____ Phone: ( ) _____

MAY 1999

AERONAUTICS ACT (1985)
MEDICAL AND OPTOMETRIC INFORMATION

Minister to be provided with information

6.5 (1) Where a physician or an optometrist believes on reasonable grounds that a patient is a flight crew member, an air traffic controller or other holder of a Canadian aviation document that imposes standards of medical or optometric fitness, the physician or optometrist shall, if in his opinion the patient has a medical or optometric condition that is likely to constitute a hazard to aviation safety, inform a medical adviser designated by the Minister forthwith of that opinion and the reasons therefor.

Patient to advise

(2) The holder of a Canadian aviation document that imposes standards of medical or optometric fitness shall, prior to any medical or optometric examination of his person by a physician or optometrist, advise the physician or optometrist that he is the holder of such a document.

Use by Minister

(3) The Minister may make such use of any information provided pursuant to subsection (1) as the Minister considers necessary in the interests of aviation safety.

No proceedings shall lie

(4) No legal, disciplinary or other proceedings lie against a physician or optometrist for anything done by him in good faith in compliance with this section.

Information privileged

(5) Notwithstanding subsection (3), information provided pursuant to subsection (1) is privileged and no person shall be required to disclose it or give evidence relating to it in any legal, disciplinary or other proceedings and the information so provided shall not be used in any such proceedings.

Deemed consent

(6) The holder of a Canadian aviation document that imposes standards of medical or optometric fitness shall be deemed, for the purposes of this section, to have consented to the giving of information to a medical adviser designated by the Minister under subsection (1) in the circumstances referred to in that subsection.

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